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EARTH RESOURCES INTERACTIVE PROCESSING SYSTEM REQUIREMENTS

Contract NAS 9-1261

NOVEMBER 1975

prepared for

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

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Space Information Systems Operation

PHO-TR514

NASA CR-
147418

EARTH RESOURCES INTERACTIVE PROCESSING SYSTEM REQUIREMENTS

1 July 1972

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
Houston, Texas

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NOTICE

The name of Philco-Ford Corporation, Aerospace and Communications Operations, Western Development Laboratories Division, Houston Operation (PHO) has been changed to Aeronutronic Ford Corporation, Aerospace and Communications Operations, Western Development Laboratories Division, Space Information Systems Operation (SISO). Due to the change in name, both the PHO and SISO abbreviations may appear in this document.

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*Complete table of contents provided at the beginning of the section.

COLLATING INSTRUCTIONS, LIST OF EFFECTIVE PAGES, AND RECORD OF CHANGES

This list shall be used as a guide in inserting change pages in JSC-10152 (SISO-TR514). The legend symbols following the change number in the EFFECTIVE CHG column denote the disposition of pages in the change. The legend symbols, defined at the foot of each page in this list, denote the following actions to be taken:

OI Original Issue of this document as PHO-TR514.

* A single asterisk denotes a page which replaces an existing page.

** Double asterisk denotes a new page to be added.

--- Three dashes denote a page to be deleted.

OI/6 Original Issue of this document as JSC-10152.

NOTE

In this change, the symbol OI/6 shall be used to denote that the OI of JSC-10152 is the same as the sixth change to SISO-TR514. Henceforth, all changes to JSC-10152 shall be denoted by a single numeral.

The following is a list of previous changes and issue dates for both SISO-TR514 and JSC-10152.

CHANGE	DATE	CHANGE	DATE	CHANGED	DATE
SISO-TR514 Changes					
OI	1 July 1972				
1	3 Nov. 1972				
2	5 Mar. 1973				
3	1 Oct. 1973				
4	3 June 1974				
5	11 Mar. 1975				
JSC-10152 Changes					
OI/6	28 Nov. 1975				

COLLATING INSTRUCTIONS, LIST OF EFFECTIVE PAGES, AND RECORD OF CHANGES

SECTION AND PAGE NO.		PREV CHG	EFF CHG
COVER			OI/6**
NOTICE			OI/6**
TITLE			OI
COLLATING INSTRUCTIONS, LIST OF EFFECTIVE PAGES, AND RECORD OF CHANGES			
	-A1-thru-A5-	5	OI/6*
FOREWORD	-ii-		OI
TABLE OF CONTENTS			
	-iii-	5	OI/6*
	-iv-	4	5*
SECTION 1	TAB		OI
1.1	-1	4	5
1.2	-1		OI
1.3	-1	OI	4
1.4	-1	OI	4
	-2	5	OI/6*
SECTION 2	TAB		OI
2.1	-1	5	OI/6*
SECTION 3	TAB	OI	OI/6*
3.1	-1	OI	OI/6*
3.2	-1	4	OI/6*

SECTION AND PAGE NO.		PREV CHG	EFF CHG
SECTION 4	TAB	OI	2
4	-i thru-iv		OI/6*
	-v		5
4.1	-1	5	OI/6*
4.2.1	-1	4	5
	-2		4
	-3		4
4.2.2	-1	4	OI/6*
	-2	4	5*
	-3 and -4		4
	-5		4*
	-6	5	OI/6*
	-7	4	5
4.3.1	-1 thru -4		5
4.3.2	-1 thru -3		5
4.4	-1 and -2	4	OI/6*
4.5	-1 and -2		4
4.6	-1 thru -3		4
4.7.1	-1	5	OI/6*
4.7.2	-1 and -2		5
	-3	5	OI/6*
4.7.3	-1 and -2		5
4.7.4	-1		5*
	-2	5	OI/6*
4.7.5	-1 and -2		5
4.7.6	-1	5	---
4.7.7	-1		5

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COLLATING INSTRUCTIONS, LIST OF EFFECTIVE PAGES, AND RECORD OF CHANGES

SECTION AND PAGE NO.		PREV CHG	EFF CHG
SECTION 4 (CONT'D)			
4.7.8	-1 and -2		5
	-3 and -4	5	OI/6*
	-5 and -6		5
	-7		5*
	-8		OI/6**
4.8.1	-1		5
4.8.2	-1	5	OI/6*
	-2 and -3		5*
	-4	5	OI/6*
	-5		5
SECTION 5	TAB	1	2
5	-i and -ii	2	4
5.1	-1	2	4
5.2	-1	2	4
5.2.1	-1		4
5.2.2	-1 and -2		4
5.2.3	-1 thru -6		4
5.2.4	-1 thru -3		4
5.2.5	-1 thru -7		4
5.2.6	-1		4
5.3	-1	2	4
5.4.1	-1 thru -6		4
5.4.2	-1 and -2		4
SECTION 6	TAB	1	2
6	-i	2	4
	-ii	4	5
6.1	-1	4	OI/6*
6.2	-1	3	4

SECTION AND PAGE NO.		PREV CHG	EFF CHG
SECTION 6 (CONT'D)			
6.2.1	-1		5
6.2.2	-1 and -2	4	5
	-3 thru -6		5
6.3.1	-1	4	5
6.3.2	-1	4	5
6.3.3	-1	4	5
6.4	-1 and -2	3	4
	-3		4
SECTION 7	TAB	OI	2
7	-i thru -iii		2
7.1	-1	2	3
7.2	-1	2	3
	-2	1	2
	-3	2	3
	-4 thru -7	1	2
	-8	2	3
	-9 thru -12		2
7.3	-1	OI	2
7.4	-1	2	3
	-2 thru -8	OI	2
SECTION 8	TAB		2
8	-i thru-viii	5	OI/6*
8.1.1	-1	5	OI/6*
8.1.2	-1 and -2	5	OI/6*
8.2	-1	3	4
8.2.1	-1		4
8.2.2	-1 thru -4	5	OI/6*

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COLLATING INSTRUCTIONS, LIST OF EFFECTIVE PAGES, AND RECORD OF CHANGES

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SECTION 8 (CONT'D)			
8.2.3	-1	5	OI/6*
	-2		5*
	-3		5
8.2.4	-1 and -2	4	OI/6*
	-3		4*
	-4 and -5	4	OI/6*
	-6 thru -9		OI/6**
8.2.5	-1 and -2	5	OI/6*
	-3	4	5
8.2.6	-1 thru -3	4	5
8.2.7	-1	5	OI/6*
	-2	4	5*
	-3 and -4	5	OI/6*
	-5	4	5*
	-6 thru -9	5	OI/6*
	-10		5*
	-11	5	OI/6*
	-12		5*
8.2.8	-1 and -2	5	OI/6*
	-3 and -4	4	5
	-5	4	5*
	-6 and -7	5	OI/6*
8.2.9	-1 thru -6	5	OI/6*
	-7 thru -9		OI/6**
8.2.10	-1	5	OI/6*
	-2	4	5*
	-3 thru -5	5	OI/6*
	-6		5*
	-7 and -8	5	OI/6*
	-9 and -10	5	---
8.2.12	-1 and -2	5	OI/6*
	-3		5
8.2.13	-1 and -2	5	OI/6*
8.3.1	-1 thru -4	4	OI/6*
	-5 thru -7	5	OI/6*
	-8		5*
SECTION 8 (CONT'D)			
8.3.2	-1 thru -4	5	OI/6*
	-5 and -6		5
	-7	5	OI/6*
	-8	5	---
8.3.3	-1 and -2	5	OI/6*
	-3	4	5
	-4 thru -6		5
8.3.4	-1 and -2	4	OI/6*
8.3.5	-1 and -2	4	---
8.3.6	-1	4	OI/6*
8.3.7	-1	5	OI/6*
	-2		5*
8.3.8	-1 thru -3		OI/6**
8.4.1	-1	4	OI/6*
8.4.2	-1	4	OI/6*
	-2		4*
8.4.3	-1 and -2	4	OI/6*
8.4.4	-1 and -2	4	OI/6*
	-3	5	OI/6*
	-4 thru -7	4	OI/6*
	-8 thru -11	5	OI/6*
	-12 thru -23		OI/6**
SECTION 9 TAB			2
9	-i and -ii	2	4
9.1.1	-1		4
9.1.2	-1		4
	-2	4	5
9.2.1	-1		4

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COLLATING INSTRUCTIONS, LIST OF EFFECTIVE PAGES, AND RECORD OF CHANGES

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SECTION 9 (CONT'D)			
9.2.2	-1	4	5
	-2 thru -4		4
	-5 thru -7	4	5
	-8		4
	-9	4	5
	-10		4
9.3.1	-1	4	5
9.3.2	-1		4
9.4.1	-1		4
9.4.2	-1		4
9.4.4	-1 thru -4		4
SECTION 10 TAB			4
10	-i and -ii		5
	-iii		5
10.1	-1		4
10.2	-1	4	5
10.2.1	-1		4
10.2.2	-1 and -2	4	5
10.2.3	-1 and -2		4
10.2.4	-1 and -2		4
10.2.5	-1 and -2	4	5
	-3		5
10.2.6	-1 and -2		4
10.2.7	-1 and -2		4
10.2.8	-1 thru -5		4
10.2.9	-1 and -2		5
10.3.1	-1		4
SECTION 10 (CONT'D)			
10.3.2	-1		4
10.3.3	-1	4	5
10.3.4	-1		4
10.3.5	-1		4
10.3.6	-1		4
10.3.7	-1 thru -6		5
10.4	-1		4

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A5-A

SECTION 1

INTRODUCTION

1.1 PURPOSE

The Earth Resources Interactive Processing System (ERIPS) is a combination of software and hardware to be implemented at JSC to provide facilities for processing remotely-sensed earth resources data. The computing facilities will be located in the Real-Time Computer Complex (RTCC) while the interactive consoles and associated display devices will be located in Building 17.

The ERIPS software will be composed of the Enhanced Operating System (EOS), an ERIPS interactive supervisor package and various applications programs. Current examples of these programs are:

A. Application Programs

- The data loading program (LOAD)
- The image registration program
- The pattern recognition program (LARSYS)
- The image manipulation and display program.
- The data clustering program

B. Supervisor Objectives

- Provide the interface between the user and his interactive equipment and the applications
- Provide the interface between the applications
- Minimize the impact of adding new applications to ERIPS
- Provide the interface between user batch card input and the applications.

The requirements detailed herein have been prepared primarily for the use of programming personnel concerned; the intent is to provide guidance for the development of the Earth Resources Interactive Processing System requirements. Secondarily, the material presented is for general reference use.

Approved: TJP NASA/DPB RWS PHO

1.2 SCOPE

This document contains both functional and detailed requirements for the Earth Resources Interactive Processing System.

Approved: ______________________ NASA/DPB ______________________ PHO

1.3 UPDATING REQUIREMENTS

Revisions and changes to this document will be prepared and published as necessary. Comments concerning necessary system changes, previous errors or more specific information should be submitted to:

J. L. Parker, Head,
Programming Support Section
Data Processing Branch
Ground Data Systems Division
Mail Code: FS-5,
Lyndon B. Johnson Space Center
Houston, Texas 77058

Approved: ______________ NASA/DPB ______________ PHO

1.4 DISTRIBUTION

Distribution of PHO-TR514 and subsequent changes shall be made by PHO Data Control in accordance with the following list. Additions, deletions, and corrections should be submitted to:

J. L. Parker, Head,
Programming Support Section
Data Processing Branch
Ground Data Systems Division
Mail Code: FS-5
Lyndon B. Johnson Space Center
Houston, Texas 77058

Approved: ________________ NASA/DPB ________________ PHO

SECTION 2

HARDWARE

2.1 INTRODUCTION

The ERIPS hardware will be composed of IBM 360/75's, a Goodyear Staran Array Processor, a data base, two Draft II consoles, two alphanumeric DTE devices, two modified DTE devices for image display (16 shades of gray), two color monitors (64 colors), and one hardcopy device.

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SECTION 3

ENHANCED OPERATING SYSTEM

3.1 INTRODUCTION

The Enhanced Operating System (EOS) is described elsewhere and will not be fully described in this section. Rather, only those aspects of EOS that are particularly pertinent to ERIPS shall be described.

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3.2 PROCESSING REQUIREMENTS

In order to make the ERIPS more nearly Operating System/360 (OS/360) compatible, only those features of the EOS available in OS/360 will be used. Any exceptions to this general rule will be noted and documented. Two such exceptions are:

A. The software required to interface with the unique terminal hardware (the XAM and DIAM access methods), and

B. The modification to the Display Formatting System (DFS) required to support the 48-bit modified DTE (Landscape TV) previously mentioned.

Approved: TJP NASA/DPB R.W.S PHO

SECTION 4

GENERAL APPLICATIONS REQUIREMENTS

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GENERAL APPLICATIONS REQUIREMENTS

4.1 INTRODUCTION

The Earth Resources Interactive Processing System (ERIPS) is an operational system to be utilized for processing remotely sensed earth resources data in both interactive and production environments. The interactive system will contain many application programs integrated into one system to provide maximum flexibility for analysis of remotely sensed data collected from spacecraft and aircraft in support of the Earth Resources E&D efforts. The production processing will support the Large Area Crop Inventory Experiment (LACIE) in a batch environment combining flexibility and production characteristics by reformatting card input data into simulated interactive inputs.

In addition, several data base functions are required to support the LACIE data processing system. In order to facilitate a modular software package, the major interfaces of the ERIPS will be controlled by the ERIPS Supervisor Program. The ERIPS Supervisor Program will provide the interface between the user and his interactive hardware, batch card input and the application software algorithms, or the interface between applications and the data bases, and there by preserve modularity of the application programs.

The Supervisor Program shall, in addition, support the interface between the 360/75 ERIPS and the STARAN Special Purpose Processor (SPP) as defined in the Interface Control Document NASA/Staran SPP, GER 16224, dated July 1975. This Interface Control Document shall be the definitive document for the functions required of the 360/75 software associated with the SPP interface. The development of this supervisor/applications software and internal interfaces within the 360/75 software shall be consistent with the definitions made in the referenced ICD. In particular, the Supervisor Program shall be required to distinguish for the Pattern Recognition Supervisor and Applications Programs, the appropriate device for the execution of several of these applications as determined by the SPP availability. The Supervisor Program shall also perform error detection and system recovery, or supervisory functions as defined in the ICD.

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4.2 SUPERVISOR PROGRAM SOFTWARE FUNCTIONS

4.2.1 General

4.2.1.1 Menu Format

The ERIPS menus format will have certain standard forms where applicable. These will include identification of time and terminal, location of error messages and application messages, and immediate action boxes that are in cases common to all applications. An example of this format is shown in Figure 4.2.1.1-1 where the time and terminal ID are upper center (time is hrs;min;sec and terminal ID is 1 or 2) and immediate action boxes are along the right side of the menu. Of course, other special immediate action boxes may be specified that are unique to an application. Those specified in Figure 4.2.1.1-1 will allow selection of the Image Manipulation and Display Application (IMD), activation of the image scroll function (SCR), a return to the next highest menu (RET), and specification of the End-of-field (EOF) and the End-of-Transmission (EOT) with the cursor as opposed to the keyboard special function keys EOF and EOT. (See paragraph 4.2.1.3.) Location of the error messages and the applications messages will be left to the discretion of the contractor, but must be consistent throughout the ERIPS.

4.2.1.2 Digital Television Equipment (DTE) Interface

It will suffice to say here that all DTE interfaces with the ERIPS software will be a Supervisor Program responsibility. (See Interactive Earth Observations Display/Control System Performance Specification, PHO document SE-25746.)

4.2.1.3 Special Function Keys

Special functions keys will be recognized by the ERIPS Supervisor Program and processed as described here. Current special function key inputs to be processed are:

Enable/Disable - E/D

Dump Immediate - DUMP

Reset Application - RSET

System Recovery Mode - SRM

Report Selection - RPRT

Release Message - RMSG

Supervisor Message Release - SMSG

Page Report Forward - PRF

Page Report Backward - PRB

Attention - ATTN

Approved: TBP NASA/DPB RNS PHO

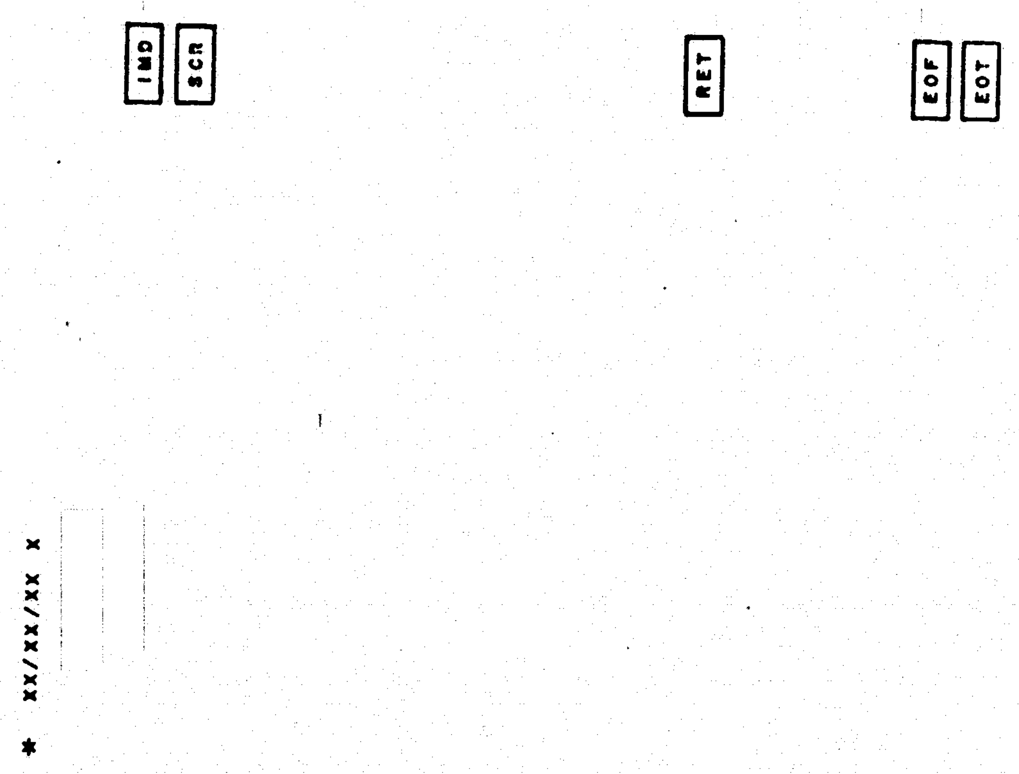

Figure 4.2.1.1-1 Typical Menu Format

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End-of-Field - EOF

End-of-Transmission - EOT

where the first column is the description and the second column is the keyboard identification.

The E/D key will activate the DUMP, RESET and SRM keys. The DUMP key, when enabled, will immediately bring down the ERIPS with a dump. The RESET key, when activated by the E/D key, will reset an application, i.e., force an ABEND to invoke application error recovery. The SRM will disable the system error recovery to bring down ERIPS when an ABEND occurs. If the SRM is struck when the E/D key has not been struck, the user will be advised of the system error recovery status. If the E/D key has been activated, the system error recovery will be changed from its present status to either enabled or disabled whichever is appropriate.

When the RPRT key is struck, the user will be transferred to the Reports menu. (See paragraph 4.5.) The PRF and PRB keys are used in the report mode and are described in Paragraph 4.5.

The RMSG key will be used to release Application or Supervisor Program status messages. The ATTN key may be used in the various applications as needed. Finally, the user will have the capability to indicate the EOF and the EOT from the keyboard as well as from the menus as described above.

4.2.1.4 Image Access

The ERIPS will store all images to be processed on disk for rapid access. The ERIPS Supervisor Program will provide the image access for the ERIPS applications.

4.2.1.5 System Error Recovery

The ERIPS Supervisor Program will be responsible for system error recovery.

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4.2.2 Sign-on

4.2.2.1 ERIPS Activation

When the ERIPS is ready for processing, the Supervisor Program will display a suitable message to the user as shown in Figure 4.2.2.1-1. Striking the EOT key will then bring up the following menus.

4.2.2.2 Coldstart/Restart Menu

The menu shown in Figure 4.2.2.2-1 will appear after the user strikes the EOT to the previous menu. The user will have the option on this menu to either coldstart the terminal or to restart the terminal. Restarting the terminal will be discussed in Paragraph 4.3 Checkpoint/Restart. Should the user cursor the Coldstart box, he will follow the normal sign-on procedure discussed here.

4.2.2.3 Sign-on Menu

The first menu in the sign-on sequence is illustrated in Figure 4.2.2.3-1. The user will enter, as shown, his name, identification information, room number, building number and his assigned FOSO and PA codes. This information will appear on delogs and the name, room number, and building will appear on microfiche output for mailing purposes.

4.2.2.4 Monitor Selection Menu

After signing onto the ERIPS, the user will have the capability to select the use of either all six monitors or only the three monitors assigned to the terminal being operated. To select all six monitors, the user will cursor the ALL SIX SCREENS box. If only three monitors are required, the user will cursor the EOT box.

4.2.2.5 Application Selection Menu

After the Sign-on and the Monitor Selection, the user will then be presented with the menu shown in Figure 4.2.2.5-1 which will allow the user to select the application required to process his data. Applications available will include the following:

Registration

Load

Pattern Recognition

Image Display

Delog

Image Creation

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The user may also sign-off the terminal which will cause the data from that run to be purged and a return to the menu of Paragraph 4.2.2.1, allowing the user to again begin sign-on procedures. The "STOP" immediate action box will bring down the ERIPS without a dump.

Approved: TGP NASA/DPB RGS PHO

HIT EOT TO BEGIN SIGN-ON

Figure 4.2.2.1-1 Sign-on

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COLDSTART/RESTART

CHECK THE DESIRED OPTION

1. RESTART THIS TERMINAL ☐

2. COLDSTART THIS TERMINAL ☐

EOF

EOT

Figure 4.2.2.2-1 Coldstart/Restart Menu

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Approved: NASA/DPB PHO

SIGN-ON

IDENTIFICATION

PLEASE FILL IN THE FOLLOWING INFORMATION.

ALL FIELDS MUST BE COMPLETED BEFORE
PROCESSING CONTINUES.

YOUR NAME	_______________
IDENTIFICATION	_______________
ROOM NUMBER	____
BLDG NUMBER	____
FOSO NUMBER	____
PA NUMBER	____

EOF

EOT

Figure 4.2.2.3-1 Sign-on Menu

Approved: NASA/DPB PHO

SIGN-ON
SCREEN SELECTION

THE THREE SCREENS ASSOCIATED WITH THIS TERMINAL WILL AUTOMATICALLY BE ASSIGNED TO YOU. IF YOU WISH TO USE ALL SIX SCREENS PLEASE CURSOR THE BOX BELOW.

ALL SIX SCREENS ☐

EOF

EOT

Figure 4.2.2.4-1 Screen Selection Menu

SIGN-ON

SCREEN SELECTION

THOSE MONITORS LISTED BELOW WITHOUT A
UA IN THEIR DECISION BOX ARE AVAILABLE
FOR SELECTION.

SELECT ANY NUMBER OF UNUSED SCREENS
WHICH YOU WANT TO BE ASSIGNED TO YOUR JOB

MONITOR 1	UA
MONITOR 2	
MONITOR 3	
MONITOR 4	UA
MONITOR 5	UA
MONITOR 6	

RET

EOF

EOT

Figure 4.2.2.4-1 Monitor Selection Menu

Approved: ______ NASA/DPB ______ PHO

APPLICATION SELECTION

STOP

LISTED BELOW ARE THE NAMES OF AVAILABLE
APPLICATION PROGRAMS
SELECT, AT MOST, ONE FOR EXECUTION

- [ ] REGISTRATION
- [ ] LOAD
- [ ] PATTERN RECOGNITION
- [ ] IMAGE DISPLAY
- [ ] DELOG
- [ ] IMAGE CREATION
- [ ] SIGN-OFF THIS TERMINAL

EOF

EOT

Figure 4.2.2.5-1 Application Menu

Approved: ______ NASA/DPB ______ PHO

4.3 CHECKPOINT/RESTART

4.3.1 Restart

If the user cursors the "Restart This Terminal" box on the menu represented in Figure 4.2.2.2-1, he will be presented with one of the menus shown in Figures 4.3.1-1 and 4.3.1-2. Figure 4.3.1-1 will appear when there is no restart data available on the ERIPS scratch disk pack. In this case, if the user wishes to complete the restart, he must type in the tape number of his restart tape. This would be the normal procedure when the user has written a restart tape from an application.

If the ERIPS scratch disk pack has restart information available, the user will have the option of using that data or using a restart tape as shown in Figure 4.3.1-2. The user will have the capability there to cursor the "Use Existing Restart Data" box to use the information on disk or to cursor the "Use a Restart Tape" box after which he will specify the tape by typing in the tape number. The first option here would be used for the case of a computer failure that would leave data on disk and the latter would be used when coming up with ERIPS scratch disk packs that contain old data not of use to the current user.

If the user specifies "Use A Restart Tape" option from either of the above menus and an image name on the restart tape already exists in the system, the menu shown in Figure 4.3.1-3 will be displayed. The user will then have the option to delete the existing image and use the image from the restart tape, to use the existing image, or to coldstart.

Data will be checkpointed periodically during ERIPS processing in order to facilitate the implementation of the above restart requirements. These checkpoints will be taken at every major menu change. When the restart is then activated, the user will be transferred to the point at which he left the ERIPS.

Approved: TBP NASA/DPB RNB PHO

NO RESTART DATA EXISTS
IF RESTART IS STILL DESIRED,
THE RESTART TAPE NUMBER
MUST BE ENTERED ______

EOF

EOT

Figure 4.3.1-1 Restart Data Unavailable Menu

Approved: ________ NASA/DPB ________ PHIO

CHECK THE DESIRED OPTION

1. USE EXISTING RESTART DATA ☐

2. USE A RESTART TAPE ☐

IF OPTION 2 ABOVE IS SELECTED, A RESTART TAPE NUMBER MUST BE ENTERED HERE ------

Figure 4.3.1-2 Restart Data Available Menu

Approved: ______ NASA/DPB ______ PHO

THE FOLLOWING IMAGE IS ON THE RESTART
TAPE AND ALREADY EXISTS IN THE SYSTEM

XXXXXXXXXXXX

SELECT ONE OF THE FOLLOWING OPTIONS

USE IMAGE FROM RESTART TAPE ☐
NOTE: THIS OPTION DELETES THE EXISTING IMAGE

USE EXISTING IMAGE ☐

COLDSTART ☐

IF N/A APPEARS IN A DECISION BOX , THIS
OPTION IS NOT AVAILABLE IN THIS CASE

Figure 4.3.1-3 Restart Image Conflict Menu

Approved: TBP NASA/DPB RNL PHO

PHO-TR514
Change 5
11 March 1975

4.3.2 Checkpoint

Data will be checkpointed periodically during ERIPS processing in order to facilitate the implementation of the restart requirements. These checkpoints will be taken at every major menu change. When the restart is activated, the user will be transferred to the point at which he left the ERIPS.

Specific menus within the applications will allow the user to write restart data to tape. When the output to tape option is selected, the menu shown in Figure 4.3.2-1 will appear advising the user that the checkpoint is being written and displaying a code name indicating from which application the checkpoint is being written. When the checkpoint processing is complete the tape number will be displayed and the user advised that the processing is complete. See Figure 4.3.2-2.

Approved: ____________________ NASA/DPB ____________________ PHO

ERIPS CHECKPOINT/RESTART

CHECKPOINT XXXXXXXX NOW BEING
UNLOADED TO TAPE. WHEN PROCESSING IS
COMPLETED THE TAPE NUMBER(S) WILL
APPEAR:

Figure 4.3.2-1 Checkpoint Restart Menu - Initial

Approved: ________ NASA/DPB ________ PHO

ERIPS CHECKPOINT/RESTART

CHECKPOINT XXXXXXXX NOW BEING UNLOADED TO TAPE. WHEN PROCESSING IS COMPLETED THE TAPE NUMBER(S) WILL APPEAR:

TAPE VOLUME ONE: XXXXXX

TAPE PROCESSING IS NOW COMPLETE. COPY TAPE NUMBERS. THEN HIT EOT TO RETURN TO NORMAL PROCESSING.

Figure 4.3.2-2 Checkpoint Restart Menu - Complete

Approved: ______ NASA/DPB ______ PHO

PHO-TR514
Change 5
11 March 1975

4.4 SPACE RECOVERY

During ERIPS processing, if the ERIPS disk space availability should prevent further processing; i.e., loading of an image or generation of an image, the menu shown in Figure 4.4-1 will appear. The user will have the capability on this menu to delete an image from disk or to unload an image to tape and delete the image from disk. This menu will also appear when the unload option is specified in the Load Application and when the user exits any of the ERIPS applications. For these instances, the menu will allow the user the option to unload an image to tape without deleting the image from disk. Also, this menu will provide information concerning the percent of disk space each image occupies and when the menu automatically appears it will inform the user how much disk space must be deleted in order to load or generate the desired image.

Approved: ______ NASA/DPB ______ PHO

```
                          *  09/22/50  I

MENU 9006                                          PAGE  1 of  1      [PAGE]
                          SPACE RECOVERY

  THE FOLLOWING IMAGES CURRENTLY EXIST ON THE ERIPA2 DISK VOLUME:

    IMAGE     C  %      IMAGE     C  %      IMAGE     C  %      IMAGE     C  %

XXXXXXXXXXXX  - XX XXXXXXXXXXXX - XX XXXXXXXXXXXX - XX XXXXXXXXXXXX - XX

XXXXXXXXXXXX  - XX XXXXXXXXXXXX - XX XXXXXXXXXXXX - XX XXXXXXXXXXXX - XX

 TO EXIT SPACE RECOVERY SELECT THE -RET- BOX.

 TO PROCEED TO THE NEXT PAGE OF IMAGES SELECT THE -PAGE- BOX.            [RET]

 TO UNLOAD AND/OR DELETE AN IMAGE, TYPE AN ACTION CODE IN THE ADJACENT FIELD.
           TYPE:   TO:
               D     DELETE WITHOUT UNLOADING TO TAPE.
               U     UNLOAD TO TAPE AND DELETE.
               K     UNLOAD TO TAPE AND NOT DELETE. (NO SPACE FREED)
                                                                          [EOF]

                                                                          [EOT]
```

Figure 4.4-1 Image Evaluation Menu

Approved: NASA/DPB PHO

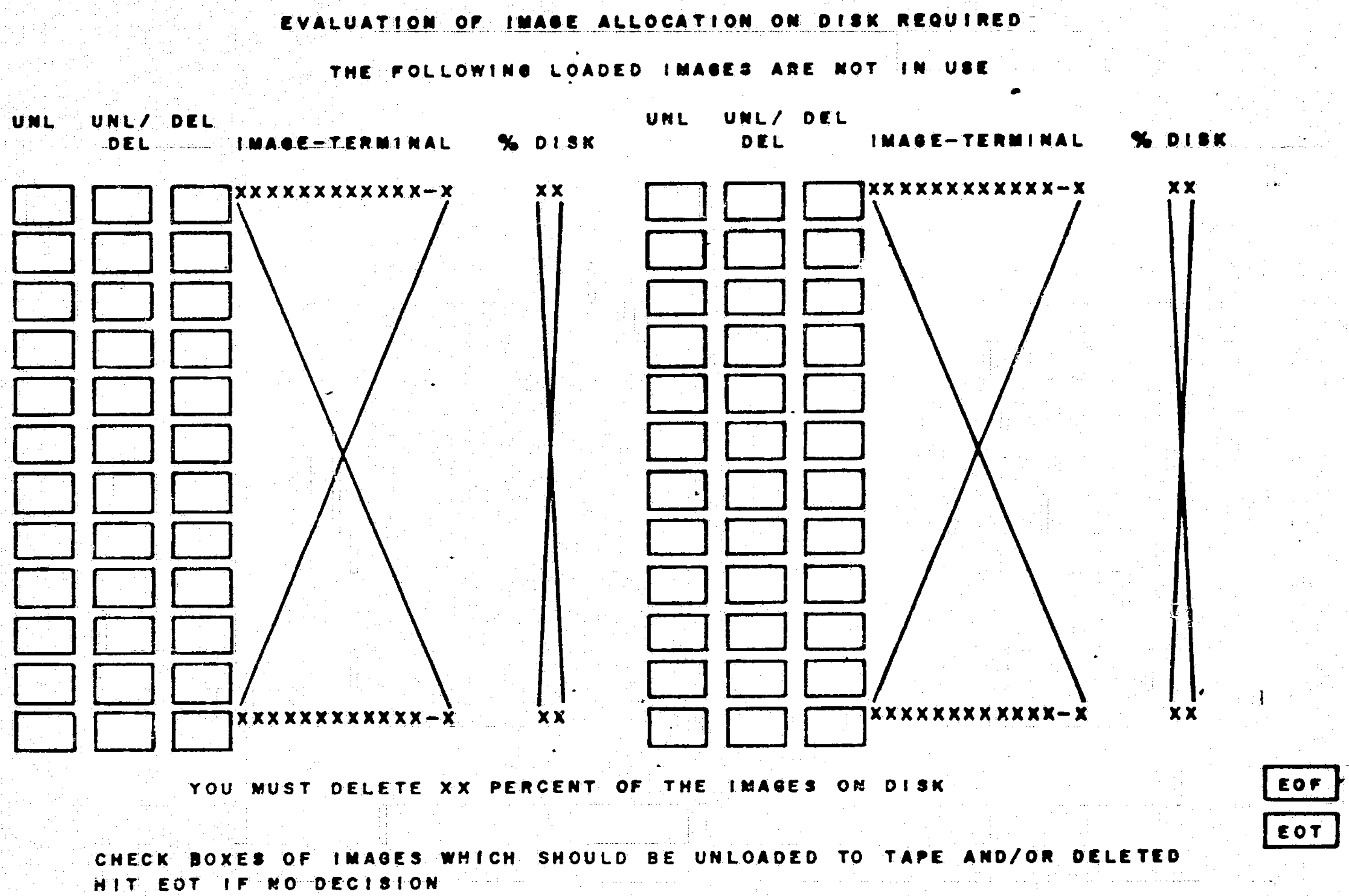

Figure 4.4-1 Image Evaluation Menu

4.5 REPORT PROCESSOR

The user will have displayed to him the menu shown in Figure 4.5-1 when he strikes the RPRT key. This menu will list the reports available to the user and the number of pages in each report. The user will be limited to 20 reports and 80 total pages. The user will be able to cursor the box alongside the report to be viewed and the box corresponding to the monitor on which it is displayed and the ERIPS will perform these actions as specified. The PRF and PRB keys will then enable the user to page forward and backward through the report. Error logic will prevent the cursoring of two or more reports for display or two or more monitors simultaneously or, the selection of a monitor that is not allocated to that terminal. If the user is deleting reports, several reports may be selected simultaneously.

When the user cursors the Exit Report Mode box, he will be returned to the location from which he struck the RPRT key.

Approved: TGP NASA/DPB RWS PHO

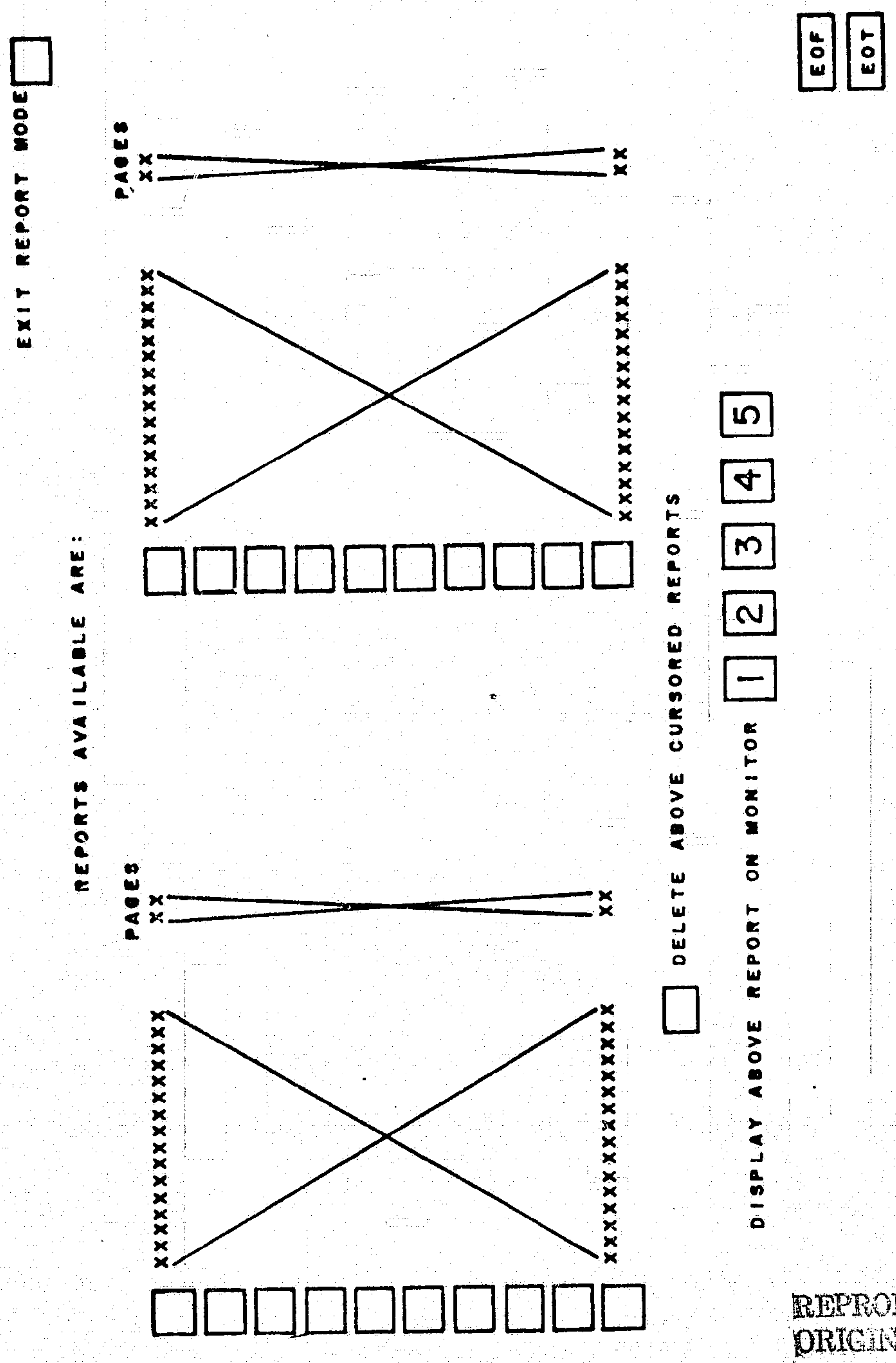

Figure 4.5-1 Report Processor Menu

Approved: ______________ NASA/DPB ______________ PHO

4.6 DELOG PROCESSOR

The user may delog his ERIPS activities, i.e., have printed the menus and reports processed during his session, if desired. The delog processor will be available via the application selection menu. When the user selects the delog application, he will be presented with the menu shown in Figure 4.6-1. On this menu, the user may request a delog of all or a subset of the applications that he has worked with by cursoring the boxes alongside each application desired. Notice that the user will have the capability to delog menus or reports or both and then may specify a beginning and ending time for the delog ('efault will be to delog the entire run).

All delog output will contain a header page as shown in Figure 4.6-2. The block letters will be generated from the first four entries in the name category of the sign-on menu. These block letters will be followed by a printout of all the sign-on information and the block letters "DELOG" identifying the output as a delog.

Approved: ____________ NASA/DPB ____________ PHO

```
                          DELOG                                          IMD
                                                                         SCR
          . PLEASE SELECT OPTIONS TO DELOG

APPLICATION             MENU        REPORT              TIME
                                                HR MM SS   HR MM SS
PATTERN RECOGNITION     [ ]         [ ]         XX XX XX   XX XX XX

IMD                     [ ]         [ ]         XX XX XX   XX XX XX

LOAD                    [ ]         [ ]         XX XX XX   XX XX XX

REGISTRATION            [ ]         [ ]         XX XX XX   XX XX XX


                                                                         RET


                                                                         EOF
                                                                         EOT
```

Figure 4.6-1 Delog Processor Menu

Approved: ______________ NASA/DPB ______________ PHO

```
FFFFFFFFFFFF   SSSSSSSSSS    DDDDDDDDD
FFFFFFFFFFFF  SSSSSSSSSSSS   DDDDDDDDDD
FF            SS        SS   DD       DD
FF            SS             DD        DD
FF            SSS            DD        DD
FFFFFFFF       SSSSSSSSS     DD        DD
FFFFFFFF        SSSSSSSSS    DD        DD
FF                     SSS   DD        DD
FF                      SS   DD        DD
FF            SS        SS   DD       DD
FF            SSSSSSSSSSSS   DDDDDDDDDD
FF             SSSSSSSSSS    DDDDDDDDD
```

```
NAME      FSD PRICE
ID        11/2/73 0615
BLDG      30
ROOM      2093
FCSD      0617
PA        3779
```

```
DDDDDDDDD     EEEEEEEEEEEE  LL            OOOOOOOOOOOO    GGGGGGGGGG
DDDDDDDDDD    EEEEEEEEEEEE  LL            OOOOOOOOOOOO   GGGGGGGGGGGG
DD       DD   EE            LL            OO        OO   GG        GG
DD        DD  EE            LL            OO        OO   GG
DD        DD  EE            LL            OO        OO   GG
DD        DD  EEEEEEEE      LL            OO        OO   GG
DD        DD  EEEEEEEE      LL            OO        OO   GG     GGGGG
DD        DD  EE            LL            OO        OO   GG     GGGGG
DD        DD  EE            LL            OO        OO   GG        GG
DD       DD   EE            LL            OO        OO   GG        GG
DDDDDDDDDD    EEEEEEEEEEEE  LLLLLLLLLLLL  OOOOOOOOOOOO   GGGGGGGGGGGG
DDDDDDDDD     EEEEEEEEEEEE  LLLLLLLLLLLL  OOOOOOOOOOOO    GGGGGGGGGG
```

Figure 4.6-2 Header Page

Approved: ______________ NASA/DPB ______________ PHO

4.7 LARGE AREA CROP INVENTORY EXPERIMENT DATA BASE

4.7.1 General

The data required to support the Large Area Crop Inventory Experiment (LACIE) is stored in five functional data bases: history, fields, imagery, control, and results. These data bases provide storage for the data required to support six application programs. Five of these programs can be operated either in batch mode or interactively from an ERIPS type terminal. The sixth, JSC I/F tape application, is a batch only program.

The total immediate access storage requirement to support these applications (near the end of the growing season) is expected to be 3.5×10^9 bytes plus data management overhead. The activity for each data base is discussed seperately.

The sample segments used for LACIE will be identified by numbers ranging 1 to 9999; however, only 4826 sample segments will reside in the data base at one time. Of the 4826 sample segments, up to 960 (16 acquisitions) may be training segments. The remaining 3866 sample segments are designated as ordinary segments.

Approved: ______ NASA/DPB ______ RWS PHO

4.7.2 History Data Base

4.7.2.1 Content

The history data base contains sample segment identification, GSFC controlling information, biological parameters, acquisition history, a tape index, data quality information, an imagery data base index, yield constants, and yield results. The data base parameters stored for each stratum are listed in table 4.7.2.1-1 and those stored for each sample segment are listed in table 4.7.2.1-2.

TABLE 4.7.2.1-1

STRATUM PARAMETERS

FIELD	PARAMETER	OCCURRENCES/STRATUM
1	Country	1
2	Region	1
3	Zone	1
4	Stratum	1
5	Area of stratum	1
6	Yield/production constants	60
7	Yield results	52

TABLE 4.7.2.1-2

SAMPLE SEGMENT PARAMETERS

FIELD	PARAMETER	OCCURRENCES/SAMPLE SEGMENT	
		ORDINARY	TRAINING & INTENSIVE STUDY
8	Sample segment number	1	1
9	Orbit number	4	16
10	GSFC tape/file no.	4	16
11	Class tape/file no.	4	16
12	Cluster tape/file no.	4	16
13	Overlay tape no.	4	16
14	Report page no.	1	1
15	Latitude	1	1
16	Longitude	1	1
17	Dates of JSC I/F updates	10	10
18	Potential acq. dates	18	18

Approved: TGP NASA/DPB RMS PHO

TABLE 4.7.2.1-2 (Continued)

FIELD	PARAMETER	OCCURRENCES/SAMPLE SEGMENT	
		ORDINARY	TRAINING & INTENSIVE STUDY
19	Actual acq. dates	4	16
20	Data quality class	4	16
21	Percent cloud cover	4	16
22	Growing season	1	1
23	Biological window flag	1	1
24	Overlap coverage flag	1	1
25	Film flag	1	1
26	Biological windows	1	1
27	Color codes	1	1
28	Scene no.	4	16
29	Ref. scene no.	4	16
30	Reg. conincidence	4	16
31	Reg. variance	4	16
32	Data proc. comments	4	16
33	Image data base protition ID	1	1
34	Date & time of image data base update	4	16

4.7.2.2 Activity

4.7.2.2.1 Initial Data Base Load

Fields 1, 2, 3, 4, 5, 6, 8, 14, 15, 16, 18, 22, 23, 24, 25, 27, and 33 created by the initial data base load program from information provided on punched cards.

4.7.2.2.2 Image Composition and Indexing Application

This program inserts data into fields 9, 10, 19, 20, 21, 28, 29, 30, 31, and 32 from the approximately 120 universal format headers on the daily GSFC input tape.

After completing image composition, the date and time are inserted into field 34. This program can also modify any field created by the initial data base load program from either punched cards or terminal input. The program also reads all fields in order to generate daily and query job reports. Searches are generally done on sample segment number.

Approved: ______ NASA/DPB ______ PHO

4.7.2.2.3 JSC Interface Tape Application

The entire history data base is read, one sample segment at a time, by this batch application program to generate the initial and update load tapes for the GSFC controlling data base. Fields 1, 8, 15, 16, 17, 22, 23, 24, 25, 26, and 27 are written to tape. Each time a tape is generated, field 17 is updated.

4.7.2.3 Structure

The data is grouped by information associated with each of the 1200 strata and information associated with each of the 4826 sample segments. There are from one to about 100 sample segments in each stratum. The total number of GSFC tape inputs for each sample segment over the growing season will vary from four, for ordinary sample segments, to 16 for training and intensive study segments. Since data is most often stored and retrieved by stratum or sample segment number, these fields are candidates for indexing. Also, the date of acquisition field is a possible candidate for indexing if the missing "ready" file report search is done on this field.

Approved: ______________ NASA/DPB ______________ PHO

4.7.3 Fields Data Base

4.7.3.1 Content

The fields data base contains, for each of 4826 sample segments, the definitions for up to five types of fields and information associated with up to 60 classes. The size and maximum occurrences for each data type is shown in table 4.7.3.1-1.

TABLE 4.7.3.1-1

FIELDS DATA BASE

FIELD	PARAMETER	SIZE EACH (BYTES)	OCCURRENCES/SAMPLE SEGMENT
1	Sample segment number	4	1
2	Field name	7	146
3	Set of 11 field vertices	44	146
	• training		60
	• test		61
	• designated other		10
	• designated unidentifiable		10
	• mean level adjustment		5
4	Class name and symbol	6	60
5	Class a priori value	1	60
6	Class threshold	1	60

4.7.3.2 Activity

4.7.3.2.1 Job Control Application

This program initially loads the fields data base and later adds, replaces, and deletes information. The data base contains field and class definitions generated in response to the daily GSFC input tape. The turn around time is expected to be from a few hours to a few days, but the average data rate should be about 120 sample segments per day with searches being generally done on sample segment number.

4.7.3.2.2 Classification and Mensuration Application

This program reads all of the fields and class information for sample segments to be classified and those required for training. Classification of a sample segment without training fields can require up to three sample segments with training. Classification of sample segments with training can require up to two additional sample segments with training. Data is generally retrieved by sample segment number which is retrieved from the signature extention pointers part of the processing control data base. The design goal is to classify 120 sample segments in eight hours.

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4.7.3.3 Structure

The complexity of the data base structure depends on a trade off between storage wasted because of unused fields and additional data base overhead resulting from a more complex structure. Even though each sample segment can have up to 146 fields, most of the 3860 ordinary sample segments will have only about 29. Since the set of field vertices is the largest parameter, if the data base is simply constructed with space for 146 fields per sample segment, about 75% of the space will be wasted. If, instead, the field definition or some small number of definitions is the unit of storage with possible multiple occurrences, then additional data base overhead will be incurred. All of the data is associated with sample segment number, therefore, this field is a good candidate for indexing.

Approved: ________________ NASA/DPB ________________ PHO

4.7.4 Image Data Base

4.7.4.1 Content

The image data base contains all of the data transmitted on the daily GSFC tapes during the entire growing season. Both header and imagery are stored so that the images can be retrieved in universal format. A maximum of four 4-channel images will be stored for ordinary sample segments and a maximum of 16 4-channel images will be stored for training and intensive study sample segments.

4.7.4.2 Activity

4.7.4.2.1 Image Composition and Indexing Application

After reading the history data base, this program renumbers the channels, modifies the header to indicate a composed image, and inserts the image into the image data base. Channels are numbered 1-4 for the first acquisition, 5-8 for the second, and so on. The universal format headers are inserted by sample segment number and type, and date of the pass. The imagery, still in universal format, first has a field added to each line indicating the range of bands present. Each line is then inserted sequenced on line number and range of bands within each line. This procedure eliminates the need to retrieve the previously stored channels for that sample segment to perform composition.

This program also performs the change accumulation part of the data base recovery procedure. Since this is the only program modifying the data base, the GSFC tapes are the only data source, a change accumulation can be preformed given only the sample segments affected and the time of last checkpoint. The program reads the history data base to determine what GSFC tapes are needed and then composes images to restore the data base to the time of the failure.

4.7.4.2.2 Classification and Mensuration Application

This program transfers images in universal format from the data base to high speed intermediate storage. Several image transfers take place simultaneously in order to maintain as high and steady a rate as possible on the interface between the data base and the intermediate storage. An image is retrieved by first retrieving the latest universal format header and then retrieving all 117 lines of as many groups of four-band lines as required, one line at a time. Previous headers are retrieved separately if parameters from earlier passes such as film bias and scaling factors or sun azimuth and elevation are required. This procedure reduces the rates which must be maintained on the interface between the data base and the intermediate storage required to support the special purpose processor. The amount of intermediate storage required for each sample segment is also reduced.

Approved: __________ NASA/DPB __________ PHO

4.7.4.2.3 Image Dump Application

This program retrieves images from the image data base and generates image tapes for output to the production film converter. Images are retrieved in the same way as with the classification and mensuration application; i.e, via card input specifying sample segment number and acquisition dates (up to four dates will be permitted).

4.7.4.3 Structure

Data is grouped by sample segment. Each time imagery is retrieved the latest header is also retrieveed. This header is searched for by sample segment number. The earlier headers are searched for by sample segment number and date of the pass. Imagery is searched for by line within the sample segment and by sets of four bands within each line. The sets are 1-4, 5-8, and so on through 13-16 for ordinary sample segments and on through to 61-64 for training and intensive study sample segments. The line number is contained in the ancillary block, and range of bands is added by the indexing and composition application.

According to universal format conventions, the length of each imagery record is 900 bytes and each header 3060 bytes. The total data base will have a latest header for each of the 4826 samples segment plus three additional for each of the 3840 ordinary sample segments and 15 additional for each of the 986 training and intensive study segments. Each ordinary sample segment will have 117 lines containing four 4-band groups and each training and intensive study segment will have 117 lines containing 16 4-band groups.

The entire data base is further partitioned both physically and logically to minimize recovery time after a data base failure which affects only some of the sample segments. It is partitioned physically by restricting sets of sample segments to sets of disk drives to minimize the number of checkpoint packs which must be mounted and the number of sample segments affected by a data base recovery. It is partitioned logically so that the image composition and indexing application can be restoring images received since the checkpoint while normal processing is taking place on the rest of the data base.

Approved: ______________ NASA/DPB ______________ PHO

4.7.5 Processing Control Data Base

4.7.5.1 Content

This data base contains the processing control parameter required by the classification and mensuration application to compute and manipulate statistics. It also has an indicator for the processing stage of a sample segment, ready or complete. The occurrences for each parameter are shown in table 4.7.5.1-1.

TABLE 4.7.5.1-1

PROCESSING CONTROL DATA BASE

FIELD	PARAMETER	OCCURRENCES/SAMPLE SEGMENT	
		ORDINARY	TRAINING & INTENSIVE STUDY
1	Sample segment no.	1	1
2	Ready flag	1	1
3	Processing complete flag	1	1
4	Automatic selection of training segment flag	1	0
5	Aggregation flag	1	1
6	Training segment numbers	3	3
7	Statistics option flags (3 flags/class)	180	180
8	Sun angle correction flag	1	1
9	Mean level adjustment flag	1	1
10	Mean level adjustment segment	1	1
11	Feature selection flag	1	1
12	Number of channels output from feature selection	1	1
13	Feature selection mode		

4.7.5.2 Activity

4.7.5.2.1 Job Control Application

The processng control data base is loaded and updated by this program from punched cards for about 120 sample segments per day. Each time a sample segment is made ready for processing the ready flag is set to true and the processing complete flag is set to false. The data base is accessed by sample segment number.

Approved: ______________ NASA/DPB ______________ PHO

4.7.5.2.2 Classification and Mensuration Application

Processing by this program is controlled by the processing control data base. The ready flags are read to determine which sample segments are to be processed. If the automatic selection of training segment flag is set, the program selects a training segment based on a prioritizing algorithm. If this flag is not set, the segments listed in field six are used for training. Statistical options are set by field 7 and the mainpulation of statistics options are set by fields 8-13. After processing the processing complete flag is set.

4.7.5.3 Structure

This appears to be a very small and simply structed data base which may be a part of the fields data base.

Approved: TBP NASA/DPB RMB PHO

4.7.6 Classification Results Data Base

4.7.6.1 Content

This data base contains some of the information generated during classification plus a measure of sample segment suitability for aggregation as determined by the analyst. There will be a total of not more than 38604 records in the data base, however, the number of records for each sample segment will be limited only by the total storage available. Each record contains:

1. Sample segment no.
2. Stratum no.
3. Percent wheat
4. Percent other
5. Percent thresholded
6. Percent unidentifiable
7. $\frac{\text{No. of pixels in DO fields}}{196 * 117}$
8. $\frac{\text{No. of pixels in DU fields}}{196 * 117}$
9. Training segments used
10. External statistic flag
11. Channels used
12. Number of linear combinations
13. Map of channels used
14. Whether run was semi-automatic or manual
15. Run number
16. Classification summary by class

4.7.6.2 Activity

4.7.6.2.1 Classification and Mensuration Application

After each sample segment is classified, this program generates a report and stores the results in the classification results data base. Upon request, the program generates an historical report of classifications from this data base and the history data base. These reports may be requested in batch and interactive mode. Searches are done on sample segment number.

4.7.6.2.2 Production Forecast Application

The classification results data base is read by this program in order to generate production forecasts for each of the 1200 strata each week.

4.7.6.3 Structure

Since searches are done on sample segment and stratum numbers, both fields are candidates for indexing.

Approved: TJP NASA/DPB RMB PHO

4.7.7 CHECKPOINT AND RECOVERY

4.7.7.1 History Data Base

Since this data base is relatively small and volatile, frequence checkpoints-to-tape will minimize the data base recovery problem. However, since four application programs update the data base, a system resident logging and change accumulation utility will be required to rebuild the data base from the checkpoint after a failure.

4.7.7.2 Fields Data Base and Processing Control Data Base

Both of these data bases are loaded by the job control application from punched card inputs. If both data bases are frequently checkpointed to tape, change accumulation can be performed quickly from the most recent card input decks.

4.7.7.3 Image Data Base

Since this is a very large data base (approximately 3.4×10^9 bytes), the checkpoint/recovery scheme must minimize the need to ever restore the entire data base and maximize the part of the data base available for normal processing during recovery. The data base is physically partitioned by restricting sets of sample segments to single or sets of disk drives. Checkpoints are then performed by disk-to-disk transfer to a spare set of disk packs. A recovery can then be performed by mounting relatively few checkpoint packs and performing change accumulation on only those.

The data base is also logically partitioned into smaller parallel structures by sample segment numbers to allow for normal processing on most of the data base while a checkpoint restore is performed on part of it and to allow for parallel processing of the image data base by multiple application. For example, composition and classification could process simultaneously or either application could operate on multiple images simultaneously.

Change accumulation for the image data base can be performed by the image composition and indexing application. The sample segment affected will have to be determined through either the data management system or application programs and be input manually along with time of last checkpoint. This program can then read the history data base to determine which GSFC tapes are required and then perform change accumulation.

4.7.7.4 Classification Results Data Base

This is a relatively small and volatile data base which is updated each time a sample segment is classified and should be checkpointed-to-tape frequently. A system logging and change accumulation will be required to rebuild the data base from a checkpoint. Eventhough only one program, the classification and mensuration application, updates the data base, the amount of computation involved in generating the data makes this program a poor change accumulation utility.

Approved: TMP NASA/DPB RMS PHO

4.7.8 Outputs

4.7.8.1 History Data Base Output

4.7.8.1.1 Daily Report

The daily report, shown in Figure 4.7.8.1.1-1, will be output to microfiche at any time that one of the entries in the report changes. One report will exist for each of the 4826 sample segments and will consist of as many pages as necessary to list all acquisitions and data processing comments. The report will contain information defining the sample segment, sample segment acquisition history, sample segment quality parameters, location information of the sample segment and data processing comments affecting the quality or normality of the same segment. Definitions of non-obvious parameters follows:

- Sample segment type – Training segment or normal segment.
- Country
- Region
- Zone
- Stratum

  } – Physical location of sample segment
- Latitude, Longitude – Center of sample segment
- Last control information update – Date of last tape generation for GSFC interface
- Biological window 1, 2, 3 & 4 – Beginning and ending dates of the four phases of the growing season
- REF SCENE – ERTS scene of reference sample segment image used for image registration/correlation
- % WHEAT – Percent of sample segment classified as wheat
- MENSURATION – Area of wheat in hectares
- PASS DATE – Day of year and year of sample segment acquisition
- GTAPE/FILE – GSFC tape number and file number of sample
- ERTS SCENE – The ERTS scene from which the sample segment was extracted
- CLD – Percent cloud cover
- DEL - Deleted
- MARG – Marginal

Approved: ________ NASA/DPB ________ PHO

```
                    INDEXED DATA REPORT FOR SAMPLE SEGMENT NUMBER XXXX     PAGE XXXX

SAMPLE SEGMENT TYPE = C                         CROP TYPES = SPRING WHEAT
COUNTRY = CCCCCCCCCCCC                          BIOLOGICAL WINDOW 1 = YYDDD TO YYDDD
REGION = XX,ZONE = XXXX, STRATUM = XXXX         BIOLOGICAL WINDOW 2 = YYDDD TO YYDDD
REFERENCE MAP 1 = CCCCCCCCCCCC                  BIOLOGICAL WINDOW 3 = YYDDD TO YYDDD
REFERENCE MAP 2 = CCCCCCCCCCCC                  BIOLOGICAL WINDOW 4 = YYDDD TO YYDDD
REFERENCE MAP 3 = CCCCCCCCCCCC
REFERENCE ERTS SCENE = CCCCCCCCC                %WHEAT=XX.X  MENSURATION=XXXXX.XX
LATITUDE = CCCC DEG CC MIN                      RUN ID = CCCCCCCCCCCC
LONGITUDE = CCCC DEG CC MIN
LAST CONTROL INFORMATION UPDATE = YYDDD

PASS  GTAPE/FILE ERTS SCENE ORBIT     REGISTRATION      PERCENT SUN ANGLE SYNC-LOSS-LINES STORAGE PROC
DATE                              SHARPNESS  P/B RATIO CLOUDS   EL    AZ   B1  B2  B3  B4 STATUS  DATE

YYDDD XXXXXX/XXX CCCCCCCCC  XXXXX  CCCCCCCC   CCCCCCCC    XX     XX   XXX XXX XXX XXX XXX STORED YYDDD
                                                                                          DEL
                                                                                          REJECT
YYDDD XXXXXX/XXX CCCCCCCCC  XXXXX  CCCCCCCC   CCCCCCCC    XX     XX   XXX XXX XXX XXX XXX ADDED  YYDDD

                            DATA PROCESSING COMMENTS
      -MANUALLY ASSISTED REGISTRATION WAS REQUIRED
      -SYNC IN BAND X COULD NOT BE MAINTAINED FOR XXX LINES
      -REFERENCE SCENE DID NOT COMPARE WITH REQUEST
      -DATE OF LAST CONTROL INFORMATION UPDATE DID NOT COMPARE WITH REQUEST
      -LINE LENGTH CORRECTION WAS REQUIRED
      -COORDINATES OF SAMPLE SEGMENT DID NOT COMPARE WITH REQUEST
```

Figure 4.7.8.1.1-1 Daily Report

- SHARPNESS, P/B RATIO - Registration accuracy parameters
- YYDDD - Dates are year and day of year
- PROC DATE — Date that the sample segment was processed; i.e., classified.

4.7.8.1.2 Query Report

The query report will be identical to the daily report. When the query specifies an index parameter above the segment level (i.e., stratum, zone, region or country), the output will be ordered by segment number.

Approved: ________________ NASA/DPB ________________ PHO

4.7.8.2 Fields Data Base Output

When the fields data base is updated, the three reports shown in figures 4.7.8.2-1, 4.7.8.2-2, and 4.7.8.2-3 will output showing first the current data base configuration for that sample segment then showing the final configuration. These reports will be annotated to indicate initial status and final status reports.

In addition, a transaction report will be generated for all updates. The header page of this report, shown in figure 4.7.8.2-4, will identify the sample segment ID acted upon, the input user ID, and the date of the transaction. The following statements will be output if all of the sample segment data is affected.

A. Sample segment IXXXX has been added to the data base - see final status report for the data.

B. All data for sample segment IXXXX has been replaced - see final status report for the data.

When selected parameters within a sample segment data record have been updated, a column of status information will be added to the left side of the appropriate output report (see figures 4.7.8.2-2 and 4.7.8.2-3.) All reports output will be annotated with user ID.

An image tape will also be output reflecting the field boundaries of the fields entered into the data base. This image will be output with the same scale as the LACIE images; i.e., 117 lines by 196 pixels.

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FIELDS DATA BASE TRANSACTION REPORT

SEGMENT ID = XXXX

CLASS = XXXXXX

CLASS SYMBOL = X

	1ST VERTEX	2ND VERTEX	3RD VERTEX	4TH VERTEX
LINE	XXX	XXX	XXX	XXX
COLM	XXX	XXX	XXX	XXX

FIELD OVERLAY TAPE NUMBER=XXXXXX,FILE=XXX

LAST DATE OF UPDATE=MM/DD/YY

Figure 4.7.8.2-1 Fields Data Base Transaction Report

Approved: ______ NASA/DPB ______ PHO

CATEGORY TRANSACTION REPORT

SEGMENT ID = XXXX

CATEGORY	PERCENT	A PRIORI	CATEGORY	PERCENT	A PRIORI
XXXXXX	XXX.X	XXX	XXXXXX	XXX.X	XXX
XXXXXX	XXX.X	XXX	XXXXXX	XXX.X	XXX

Figure 4.7.8.2-2 Category Transaction Report

Approved: ______ NASA/DPB ______ PHO

```
                                FIELDS TRANSACTION REPORT

 FIELD   TYPE FIELD       1ST   2ND   3RD   4TH   5TH   6TH   7TH   8TH   9TH   10TH
   ID    AND CLASS       VERTX VERTX VERTX VERTX VERTX VERTX VERTX VERTX VERTX VERTX
SUBCLASS SYMBOL

 XXXXXX    X     X  LINE XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
                    COLM XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
                    LINE
                    COLM
                    LINE
                    COLM
                    LINE
                    COLM
                    LINE
                    COLM
                    LINE
                    COLM
                    LINE
                    COLM
                    LINE
                    COLM
                    LINE
                    COLM
 XXXXXX    X     X  LINE XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
                    COLM XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
```

Figure 4.7.8.2-3 Fields Transaction Report

Approved: ____________ NASA/DPB ____________ PHO

```
FIELDS DATA BASE TRANSACTIONS

        SEGMENT  ID = IXXXX

USER ID=XXXXXXXXXXXXXXXXXXXXXXX DATE OF TRANSACTION = XXXXX
```

Figure 4.7.8.2-4 Fields Data Base Transaction Report

Approved: ______________________ NASA/DPB ______________________ PHO

4.8 BATCH PROCESSING CONTROL

4.8.1 Introduction

The processing control data base will be updated via card input on a daily basis. The classification and mensuration subsystem will then access the processing control data base to ascertain the automatic data flow for each segment to be classified and to determine what subsets of training segments are required for statistics computations. All required data will then be retrieved and the segment processed automatically in the manner specified by the processing control information.

Approved: TRP NASA/DPB RMB PHO

4.8.2 Input

Processing control cards will be input in a format similar to the card format given below. Input preprocessing will then involve reformatting the data into the data base in a format that will simulate inputs to the ERIPS menus to allow the batch operation. These inputs may be stored individually by segment ID or with pointers-to-segments that have identical processing flows.

4.8.2.1 Card Format

- Card 1

  NAME = XXXXXXXXXXXXXXXXXXXXXXXX LOOP

  Beginning in column 1 will be the keyword "NAME", followed by the user name (maximum 24 characters). The keyword "LOOP" beginning in column 32 will activate a looping sequence to process the first segment on the RSEG card along with the segments specified on the TSEG cards. Only the RSEG segment will be processed for the remaining segments on the RSEG card.

- Card 2

  RSEG = XX,XX,XXXX,XXX, (XXX),XX,X

  Beginning in column 1 will be the keyword "RSEG" identifying the card as a recognition segment definition card. Following the equals sign separated by commas will be a list of segment ID's of the recognition segment to be processed according to the following control cards. All of these recognition segments will be processed with the identical control with one exception. The fifth entry on the RSEG card, enclosed in parenthesis, will be processed without using statistics from its own training fields. All such segments will be enclosed within parenthesis as shown. An entry in column 80 will specify the next RSEG card as a continuation card.

- Card 3

  CSEG = XXXX (XXXXX, XXXXX, XXXXX, XXXXX)

  Beginning in column 1 will be the keyword identifier " CSEG ". Following the equals sign will be a segment ID with the acquisition dates of the segment to be used for processing listed within parenthesis separated by commas. If there is no segment ID, the list of channels will be used for all recognition segments of card 2. One card 3 may exist for each recognition segment identified on card 2. Also, the user may submit one card with a blank ID and then override those acquisition dates for other specified recognition segments on following cards.

- Card 4

  TSEG = XXXX (XXXXX, XXXXX, XXXXX, XXXXX)

  The keyword for card 4 will be "TSEG" with a training segment ID following the equals sign. Then enclosed in parenthesis and separated by commas will be the acquisition dates of the training segment. There will be up to three of these cards.

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- Card 5 through 15

Cards 5 through 15 will specify the user desired statistics options. One card will be input for each process to be performed, but multiple class inputs may be specified on a single card or a continuation card. Again, a continuation will be indicated by a punch in column 80 of the previous card. The keyword will be repeated on all continuation cards. The suggested formats and descriptions of each statistics option card follows below.

- Card 5

CLCC = XX,XX,XX,XX

The keyword "CLCC" will identify the card as a channels to be used for clustering card. The channels separated by commas will then follow the equals sign. Absence of this card will cause all channels to be used. It should be noted that the channel numbers at this point will not correspond to the original numbers but will have been renumbered consecutively from 1 to N, where N is the total number of channels. Error checking should be performed to ensure that this is the case. Only one CLCC card may be input and the card will apply to all recognition segments of card 2.

- Card 6

CLU1 = XXXX(XXXXXX,XXXXXX,XXXXXX,XXXXXX)

The keyword "CLU1" specifies that the clustering processor will be performed using a "DEFAULT1" parameters on the clustering initialization menu. After the equals sign a four character name will be specified as the class that the clusters will be assigned to as subclass names of XXXX01 through XXXX10 for input on the clustering report menu. If a four character name XXXX is repeated, processing control will assign subclass names XXXX11 through XXXX20 to the second set, XXXX21 through XXXX30 to the third set and so forth for each occurrence of the four character name on a separate input statistics option card for clustering. Following this four character name on the input card will be category, or subclass names to be clustered. These names will be input on the clustering area definition menu. If continuation cards are required, the indication of that fact will be as previously described.

- Card 7

CLU2 = XXXX(XXXXXX,XXXXXX,XXXXXX,XXXXXX)

Same as "CLU1" but using "DEFAULT2" parameters on the clustering initailization menu. "DEFAULT2" parameters request a maximum of 20 clusters so that subclass name assignments will be XXXX01 through XXXX20, XXXX21 through XXXX40 and so forth for each occurrence. Again, continuation cards are permitted, if required.

Approved: TBP NASA/DPB RMS PHO

- Card 5 through 15

Cards 5 through 15 will specify the user desired statistics options. One card will be input for each process to be performed, but multiple class inputs may be specified on a single card or a continuation card. Again, a continuation will be indicated by a punch in column 80 of the previous card. The keyword will be repeated on all continuation cards. The suggested formats and descriptions of each statistics option card follows below.

- Card 5

CLCC = XX,XX,XX,XX

The keyword "CLCC" will identify the card as a channels to be used for clustering card. The channels separated by commas will then follow the equals sign. Absence of this card will cause all channels to be used. It should be noted that the channel numbers at this point will not correspond to the original numbers but will have been renumbered consecutively from 1 to N, where N is the total number of channels. Error checking should be performed to ensure that this is the case. Only one CLCC card may be input and the card will apply to all recognition segments of card 2.

- Card 6

CLU1 = XXXX(XXXXXX,XXXXXX,XXXXXX,XXXXXX)

The keyword "CLU1" specifies that the clustering processor will be performed using a "DEFAULT1" parameters on the clustering initialization menu. After the equals sign a four character name will be specified as the class that the clusters will be assigned to as subclass names of XXXX01 through XXXX10 for input on the clustering report menu. If a four character name XXXX is repeated, processing control will assign subclass names XXXX11 through XXXX20 to the second set, XXXX21 through XXXX30 to the third set and so forth for each occurrence of the four character name on a separate input statistics option card for clustering. Following this four character name on the input card will be category, or subclass names to be clustered. These names will be input on the clustering area definition menu. If continuation cards are required, the indication of that fact will be as previously described.

- Card 7

CLU2 = XXXX(XXXXXX,XXXXXX,XXXXXX,XXXXXX)

Same as "CLU1" but using "DEFAULT2" parameters on the clustering initailization menu. "DEFAULT2" parameters request a maximum of 20 clusters so that subclass name assignments will be XXXX01 through XXXX20, XXXX21 through XXXX40 and so forth for each occurrence. Again, continuation cards are permitted, if required.

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- Card 8

CCH1 = XXXX(XXXXXX,XXXXXX,XXXXXX,XXXXXX)

Same as "CLU1" but perform chaining of clusters. In this case subclass names will be input on the cluster chaining menu.

- Card 9

CCH2 = XXXX(XXXXXX,XXXXXX,XXXXXX,XXXXXX)

Same as "CCH1" but use "DEFAULT2" parameters.

- Card 10

BCHN = XXXX (XXXXXX,XXXXXX,XXXXXX,XXXXXX)

The keyword "BCHN" will specify BHATTRCHARYYA chaining of field or classes is to be performed. Again, the four character name will be assigned to the resultant chains as subclass names. Processing control will assign subclass names XXXX01 to XXXNN, where NN is the number of classes identified within the parenthesis on this card. Continuation cards permitted, if necessary.

- Card 11

COMB = XXXXXX(XXXXXX,XXXXXX,XXXXXX)

Card 11 will specify that the normal computation of statistics is to be utilized. The keyword "COMB" will begin in column 1 with the class or subclass name to be assigned to the statistics following the equals sign. If a name is specified, processing control will built inputs to select the combine classes statistics option, insert the name in the new class name slot (using the first character of the name as symbol), and then input the class or subclass names specified within the parenthesis as the list of classes to be combined. If a card is not input, only the normal computation of statistics will be performed and individual statistics will be reatined.

- Card 12

EXTN = XXXXXX

The keyword "EXTN" will cause external statistics to be read in for all classes from the tape identified by the number following the equal sign. When external statistics are read, no further statistics processing will be performed.

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- Card 13

STAT = XXXXXX

A request to output statistics will be identified on card 13 with the keyboard "STAT", no tape number is necessary, but if the user wishes to write to a specific tape he may do so by indicating the number following the equals sign on this card. Otherwise the data will be written to a scratch tape. Provisions here must be made for identifying the scratch tape number to the user.

- Card 14

SUN0 = XXXXXX,XXXXXX,XXXXXX,XXXXXX
SUN1 = XXXXXX,XXXXXX,XXXXXX,XXXXXX
SUN2 = XXXXXX,XXXXXX,XXXXXX,XXXXXX
SUN3 = XXXXXX,XXXXXX,XXXXXX,XXXXXX

The keyword "SUN" will indicate that the classes or subclasses listed following the equals sign are to be corrected for sun angle. The numerical value of the keyword indicates which training segment sun angle is to be used for the correction with the 0, 1, 2, or 3 corresponding to the "RSEG" and the "TSEG's" in order. The user may specify "ALL" on each of the above cards to correct all subclasses within a segment.

- Card 15

MLAO = XXXXXX,XXXXXX,XXXXXX,XXXXXX
MLA1 = XXXXXX,XXXXXX,XXXXXX,XXXXXX
MLA2 = XXXXXX,XXXXXX,XXXXXX,XXXXXX
MLA3 = XXXXXX,XXXXXX,XXXXXX,XXXXXX
MLAV = XXXXXX,XXXXXX,XXXXXX,XXXXXX

The rules for this card will be the same as card 14. The keyword MLA will identify the card as a mean level adjustment request for the listed classes or subclasses. For mean level adjustment though, if the MLAV keyword option is specified, the average of all MLA fields contained within all training segments will be used to perform the correction. Again the user may specify all classes.

- Card 16

FSEL = WRO (, CAT = X)
FSEL = ALL (, CAT = X)
FSEL = X,X,X,XX (, CAT = X)

The keyword "FSEL" will identify the feature selection option card. This card will specify whether the without replacement option (WRO above) is to be exercised, separability for all channels (ALL above) is to be computed, or separability for all channels and a subset of channels (X,X,X,XX above) is to be computed. The CAT = X shown in brackets above denotes that the summation in the feature selection processor is to be carried to the category level for category X. If the input option is FSEL = X,X,X,XX then the channel subset X,X,X,XX will also be used for classification. If no feature selection option card is present and the number of available channels is greater than eight, the WRO option will be exercised, or if the number of channels is less than or equal to eight the ALL option will be exercised.

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- Card 17

THRS = (X,XXX.X), (X,XXX.X), (X,XXX.X)

The keyword "THRS" will identify card 17 as the threshold definition card. Then following the equals sign and enclosed in parenthesis will be the category and the threshold that applies to that category. Values input on card 17 will override the values stored on the fields data base. Continuation cards will be allowed as defined earlier.

- Card 18

APRI = (X,XXX), (X,XXX), (X,XXX)

The keyword "APRI" will define the category a priori card. This card will obey the same rules as the "THRS" card.

- Card 19

CCAT = X,X,X,X

The categories that the user wishes to sum to the category level in the classification algorithm will be defined on card 19 identified with the keyword "CCAT". The categories will be listed separated by commas after the equals sign.

Approved: TJP NASA/DPB RMB PHO

SECTION 5

LOAD REQUIREMENTS

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LOAD REQUIREMENTS

5.1 INTRODUCTION

Since the ERIPS is expected to have many future applications, each performing its operations on data generated by various sensors, the LOAD program will be designed to accept data and put it in a standard format for use by the various applications. The Load Application will have the capabilities to; load an image, unload an image, scroll images from tape, and display reports containing certain ancillary data information.

The LOAD Application must accept data from the following sensors:

- ERTS MSS
- Any sensor in LARSYS format
- Any sensor in UNIVERSAL format

The Load Application also must accept ancilliary data, although the only use at this time is for display purposes. Other application requirements of the ancillary data will be defined later.

Approved: ________________ NASA/DPB ________________ PHO

5.2 USER INTERFACE REQUIREMENTS

The ERIPS user should be able to select the Load Application immediately after signing onto the system. This selection will be made from the Application Selection Menu.

Approved: [signature] NASA/DPB [signature] PHO

5.2.1 General Capabilities

The capability will exist on all menus to indicate the End-of-Field (EOF) and End-of-Transmission (EOT) without use of the keyboard. The user may also return to the previous menu by indicating Return (RET) on any of the menus in this application.

All displayed images in this application will include a position indicator (line and column) on the overlay of the upper right hand corner and the lower left hand corner. The corner positions will be updated when the image(s) scroll is halted.

Approved: TJP NASA/DPB RWS PHO

5.2.2 Load Application Options Menu

The initial menu displayed, ERIPS Load Program (figure 5.2.2-1) will request the user to specify the option of the load application he wishes to exercise. These options will include; LOAD AN IMAGE FROM TAPE, LOAD/SCROLL FROM TAPE, DISPLAY HEADER REPORT, and UNLOAD AN IMAGE TO TAPE. Next the user will be requested to type in the image tape number(s) he wishes to process. Also, the user may specify a particular file to be loaded.

Approved: TAP NASA/DPB RNS PHO

Approved: NASA/DPB PHO

ERIPS LOAD PROGRAM

SELECT ONE OF THE FOLLOWING OPTIONS
BY POINTING AT THE CORRESPONDING BOX

[LI] LOAD AN IMAGE FROM TAPE
[LS] LOAD/SCROLL FROM TAPE
[DR] DISPLAY HEADER REPORT
[UI] UNLOAD AN IMAGE TO TAPE

(TYPE IN THE FOLLOWING)

IMAGE SOURCE TAPE NUMBERS

1147 1952 ____ ____
____ ____ ____ ____

FILE SEQUENCE NUMBER __ (DEFAULT IS 1)

[RET]

[EOF]

[EOT]

Figure 5.2.2-1 ERIPS Load Program

5.2.3 Load An Image From Tape Option

If the user selects to load an image from tape, he will be presented with the tape header report menu(s), (Refer to paragraph 5.4). Each header report will consist of three pages that will be accessed by hitting the EOT key. At any point in the tape header report, the user may elect to do either a full tape load or a subset load. If the user elects to do a full tape load (FTL) from the tape header report (full image, all channels), the Post-Load Report Menu will appear (figure 5.4.2-1), summarizing the contents of the loaded image. If the user selects the subset load (CHD) from the tape header report, the following menus will appear. The Image Subset Definition - Name Menu (figure 5.2.3-1), allows the user to either assign a 12 character alphabetic name or use a system generated name for the image to be loaded. The Image Subset Definition - Channel Menu (figure 5.2.3-2) allows the user to load all channels, or a subset of the channels. The Image Subset Definition - Boundary Menu (figure 5.2.3-3), allows the user to select the boundary technique he desires. The options will be; default limits (all pixels, all lines), geographic coordinates, line/pixel values, and pointed inputs. The user may also compress the image by specifying a line and/or a pixel skip factor. If the user has specified the line/pixel option on the boundary technique menu, the next menu to appear will be the Image Subset Definition - Limits Menu (figure 5.2.3-4). This menu will request the user to specify either line/pixel or point techniques and to supply the appropriate values. It should be noted that the user will be able to return to the previous menu from the current menu until loading begins. If the user selects a full tape load (FTL) from any of the tape header display pages, the ERIPS will generate an image name to be displayed to the user in the Post-Load Report display (paragraph 5.4.2).

Universal format allows continuation tapes, so when loading a universal format tape the user will have the option to type in the continuation tape number or simply hit EOT to complete the load (figure 5.2.3-5). The post-load display will then appear.

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IMAGE SUBSET DEFINITION

☐ CHECK BOX TO USE SYSTEM-GENERATED NAME

ELSE, ENTER NAME FOR IMAGE IDENTIFICATION

__________ (ENTER 1 TO 12 ALPHABETIC CHARACTERS)

CUE

RET

EOF

EOT

Figure 5.2.3-1 Image Subset Definition - Name

Approved: ______ NASA/DPB ______ PHO

Approved: NASA/DPB PHO

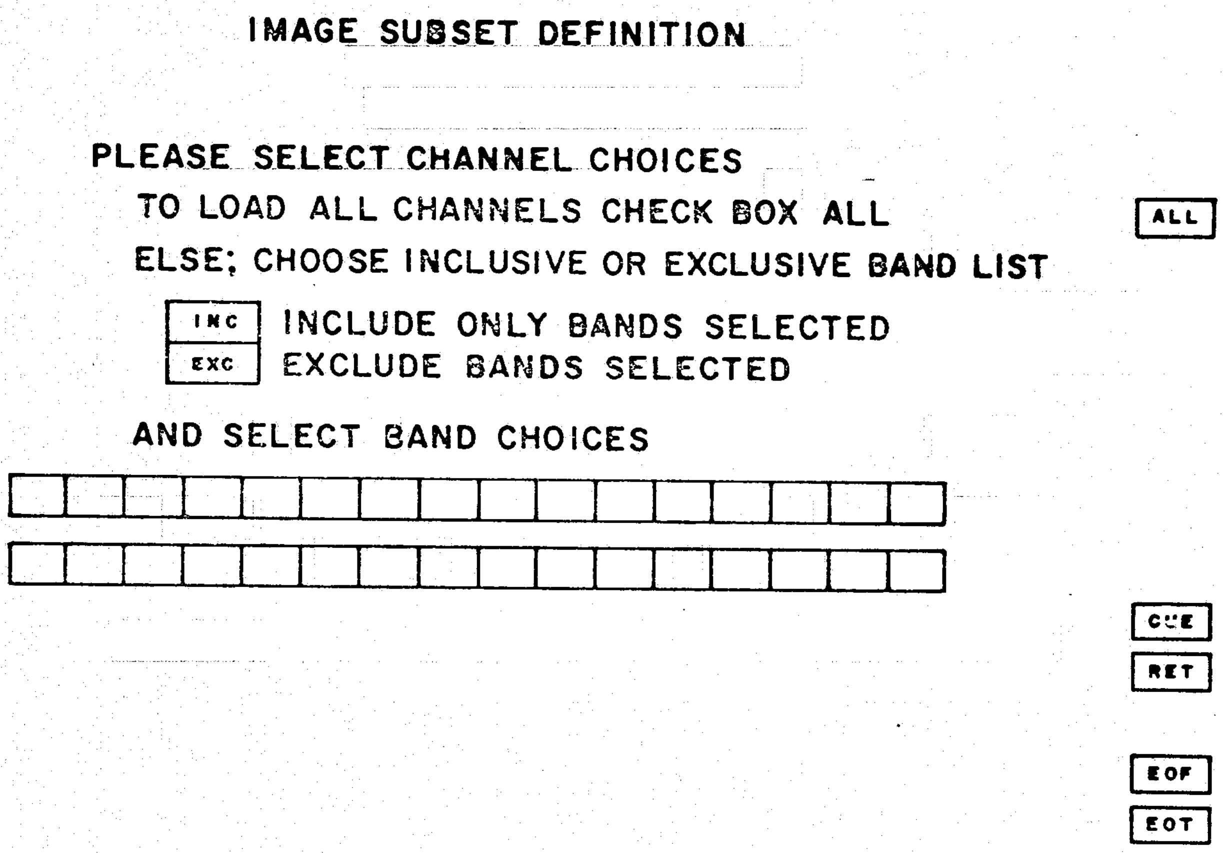

Figure 5.2.3-2 Image Subset Definition - Channel

PHO-TR514
Change 4
3 June 1974

IMAGE SUBSET DEFINITION

FTL

PLEASE SELECT BOUNDARY TECHNIQUE

DL	DEFAULT LIMITS (USE DEFAULT LINE, ALL PIXELS, ALL BANDS)
GC	GEOGRAPHIC COORDINATES (IF AVAILABLE)
LC	LINE/COLUMN VALUES
PI	POINTED INPUTS (ONLY VALID IN LOAD/SCROLL MODE)

THEN IF YOU WISH IMAGE COMPRESSION

ENTER LINE SKIP FACTOR __

AND/OR PIXEL SKIP FACTOR __

HIT EOT

CUE

RET

EOF

EOT

Figure 5.2.3-3 Image Subset Definition - Boundary

IMAGE SUBSET DEFINITION

DESIGNATE IMAGE SUBSET LIMITS

TO USE LINE/PIXEL COUNT TECHNIQUE

☐ CHECK LPC BOX AND ENTER THE FOLLOWING:

____ TYPE IN FIRST LINE VALUE
____ TYPE IN NUMBER OF LINES REQUESTED
____ TYPE IN FIRST PIXEL VALUE
____ TYPE IN NUMBER OF PIXELS REQUESTED

ELSE, TO USE BOUNDARY POINTS TECHNIQUE:

☐ CHECK BOX BP AND ENTER FROM 1 TO 4 LINE/PIXEL SETS

____ TYPE IN LINE VALUE FOR POINT 1
____ TYPE IN PIXEL VALUE FOR POINT 1
____ TYPE IN LINE VALUE FOR POINT 2
____ TYPE IN PIXEL VALUE FOR POINT 2
____ TYPE IN LINE VALUE FOR POINT 3
____ TYPE IN PIXEL VALUE FOR POINT 3
____ TYPE IN LINE VALUE FOR POINT 4
____ TYPE IN PIXEL VALUE FOR POINT 4

RET

EOF

EOT

Figure 5.2.3-4 Image Subset Definition - Limits

Approved: ______ NASA/DPB ______ PHO

```
END OF DATA FOR TAPE XXXXXX
IF YOU HAVE A CONTINUATION TAPE
PLEASE TYPE NUMBER XXXXXX
ELSE HIT EOT
```

RET

EOF
EOT

Figure 5.2.3-5 Continuation Request

Approved: ______________ NASA/DPB ______________ PHO

5.2.4 Unload an Image to Tape Option

The Image Allocation Menu (figure 5.2.4-1) will be displayed if the user selects the unload an image to tape option. This menu will list the loaded images that are not presently in use. The user will then check the boxes opposite the images that are to be unloaded to tape and deleted from disk storage, unloaded to tape but not deleted, or simply deleted. The Unloaded Images Menu (figure 5.2.4-1) should then be displayed listing the images that were unloaded and the corresponding tape numbers of the tapes to which they were unloaded. This procedure is described in paragraph 4.4 and illustrated in figure 4.4-1.

Approved: ______________ NASA/DPB ______________ PHO

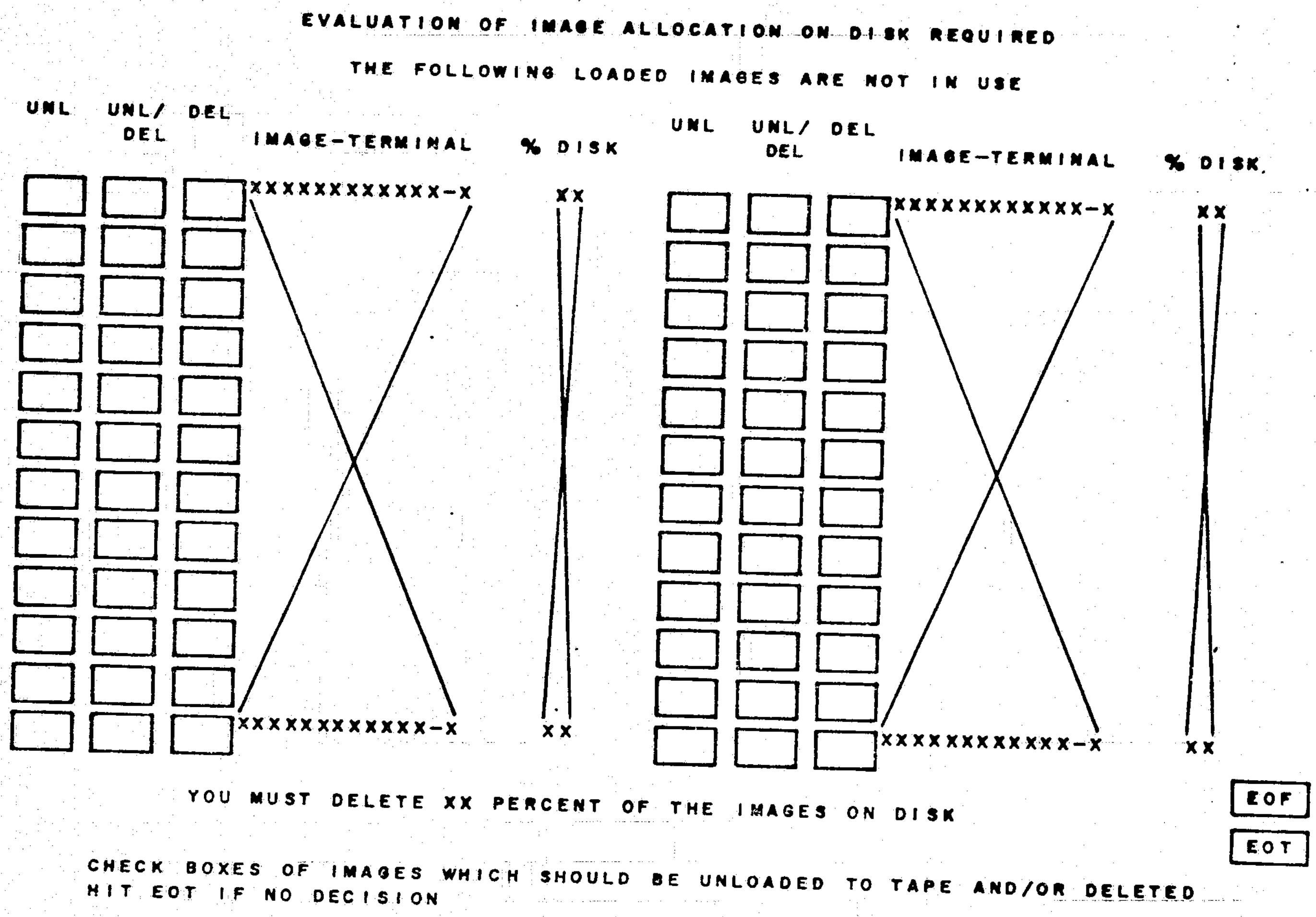

Figure 5.2.4-1 Image Allocation Menu

Approved: ________ NASA/DPB ________ PHO

```
THE FOLLOWING IMAGES HAVE BEEN UNLOADED TO THE CORRESPONDING TAPES
             SAVE THESE TAPE NUMBERS FOR FUTURE REFERENCE
IMAGE    -TAPE   IMAGE    -TAPE    IMAGE    -TAPE    IMAGE    -TAPE



HIT EOT WHEN FINISHED                                          EOF
                                                               EOT
```

Figure 5.2.4-2 Unloaded Images Menu

Approved: ______________ NASA/DPB ______________ PHO

5.2.5 Scroll/Load from Tape Option

This option will allow the user to screen an image on the image display (without first loading the image onto disk) and select th· portion of the image he wants loaded. The first menu, Image Screen (figure 5.2.5-1),will allow the user to select a screen on which to scroll the image. However, this menu will not appear if the user has only signed onto one screen.

After selecting the scroll/load option, specifying the tape number(s) to be used, and selecting a screen, if necessary, the Scroll Limits Menu (figure 5.2.5-2) will be displayed. This menu will allow the user to specify the image set dimensions, line and pixel skip factors, a magnification factor, and the channel to be scrolled. The user may use the default option, which will start scrolling at the beginning of the tape with band 1 and display the first pixel through the next 612 pixels or the last pixel of a line, whichever is smaller. The image should then be scrolled and when the area of interest to the user comes into view, the user will be able to halt the scrolling by depressing the HOLD button on the console. Depression of the HOLD button will automatically cause the Scroll Options menu (figure 5.2.5-3) to be displayed and display as an overlay the upper right and lower left corner line and pixel values. The user will then have the option of canceling scroll, continue scroll, cancel load, or start load at this time.

If the user elects to start the loading process at this time the menus discussed in paragraph 5.2.3 (figures 5.2.3-1, 5.2.3-2, 5.2.3-3, and 5.2.3-4) will be displayed. The inputs to these menus will be identical to those described in paragraph 5.2 3 with one exception; the load/scroll from tape option will allow the selection of pointed inputs (figure 5.2.3-3). If the user elects to use pointed inputs, the Image Subset Definition - Pointed Inputs Menu (figure 5.2.5-4) will be displayed allowing the user to specify from one to four points on the image screen. Each point will be marked on the overlay with a crosshair as it is identified and if more than one point is chosen, this will indicate a rectangular area is to be loaded. After completion of the load the user will have the option of continuing the scroll as shown in figure 5.2.5-5. The scrolling of the image will again start and when the scrolling is halted, the Scroll Options Menu (figure 5.2.5-3) will be displayed allowing the user to repeat the above described options.

If only one point is chosen in response to the Image Subset Definition - Pointed Inputs Menu (figure 5.2.5-4) the load process will continue until the scrolling is halted and the Scroll Options Menu (figure 5.2.5-3) appears. Then if the user selects the cancel load option the End of Load Menu (figure 5.2.5-6) will be displayed. This menu gives the user two choices of designating the end of image set. He may point at some line on the image display and it will be used as the last line, or hit EOT and the newest line on the display will be used as the default end of image set. Again as the Load an Image from Tape Option, the Post-Load Report will be displayed describing the image that was loaded. The user may load a subset of the total scrolled image, but if he wishes to load data preceeding the present location of the scrolling he must redefine the starting location and again start the scroll by selecting the RESET SCROLL box (figure 5.2.5-3).

Approved: TGP NASA/DPB RMS PHO

THIS CONVERSATIONAL TERMINAL HAS SIGNED ON TO 2 IMAGE SCREENS

PLEASE CHOOSE THE ONE YOU WISH TO SCROLL TO, AND HIT EOT

☐ COLOR SCREEN

☐ GRAY SCREEN

RET

EOF

EOT

Figure 5.2.5-1 Image Screen

Approved: ______________ NASA/DPB ______________ PHO

REQUESTED OPTION: SCROLL

DEFINE SCROLL INPUT SET LIMITS

TO USE DEFAULT SET LIMITS, POINT HERE [DL]

DEFAULTS (PIXEL 1 = 1 PIXEL COUNT = 612 LINE COUNT = SET SIZE CHANNEL = 1)

PLEASE TYPE IN SET LIMITS

FIRST PIXEL ____

LAST PIXEL ____

FIRST LINE ____

LAST LINE ____

PIXEL SKIP FACTOR __

LINE SKIP FACTOR __

MAGNIFICATION FACTOR __

CHANNEL TO BE SCROLLED __

[RET]

[EOF]

[EOT]

Figure 5.2.5-2 Scroll Limits

Approved: ________ NASA/DPB ________ PHO

Approved: ____________ NASA/DPB ____________ PHO

SCROLL OPTIONS

(PLEASE CHECK BOX TO INDICATE CHCICE)

☐ CANCEL SCROLL

☐ CONTINUE SCROLL

☐ CANCEL LOAD

☐ START LOAD

☐ RESET SCROLL

RET

EOF

EOT

Figure 5.2.5-3 Scroll Options

IMAGE SUBSET DEFINITION

SUBSET DEFINITION BY POINTED INPUTS

(THIS OPTION ONLY VALID WITH LOAD-WHILE-SCROLL)

ENTER BOUNDARY POINTS BY POINTING AT IMAGE SCREEN
AND ENTERING 1 TO 4 POINTS-THEN HIT EOT

CUE
RET

EOF
EOT

Figure 5.2.5-4 Image Subset Definition - Pointed Inputs

Approved: ______ NASA/DPB ______ PHO

TO CONTINUE SCROLLING

SELECT SCROLLING RATE AND THEN HIT EOT

RET

TO CONTINUE HIT EOT, ELSE
TO CANCEL OPTION CHECK BOX RET

EOF

EOT

Figure 5.2.5-5 Scroll Rate

Approved: ______________ NASA/DPB ______________ PHO

EOF EOT

PLEASE POINT AT IMAGE SCREEN TO INDICATE
END OF LOAD IMAGE SET AND HIT EOT SW

Figure 5.2.5-6 End of Load

Approved: ______________ NASA/DPB ______________ PHO

5.2.6 Display Header Option

This option will allow the user to display the ancillary data content from the image tape header. The menu for this option is shown in figure 5.2.3-1. The displays for this option are discussed in paragraph 5.4.

Approved: ____________ NASA/DPB ____________ PHO

5.3 PROCESSING REQUIREMENTS

The software should reformat all sensor data to one common format (UNIVERSAL), and provide all of the interactive capabilities described in paragraph 5.2. The following is a complete list of data sources with references to format documents:

- ERTS MSS - *ERTS Data Users Handbook*, GSFC 715-D4249 and *Earth Resources Data Format Control Book*
- LARSYS - *Earth Resources Data Format Control Book*
- UNIVERSAL - *Earth Resources Data Format Control Book*

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5.4 OUTPUTS

5.4.1 Header Displays

The displays generated by the load application may be requested by the load program options menu or displayed automatically. The displays will be composed of ancillary data extracted from the header records of the image tapes. The first page of the display will vary from sensor to sensor, such as: ERTSA MSS bulk format, page 1 (figure 5.4.1-1); UNIVERSAL format, page 1 (figure 5.4.1-2); and LARSYS II format, page 1 (figure 5.4.1-3). The second and third pages are the same for all sensors, figures 5.4.1-4 and 5.4.1-5, respectively.

Approved: ______________ NASA/DPB ______________ PHO

```
                    ERTSA MSS BULK ANCILLARY DATA DISPLAY                          CHD
                                                                                   FTL
TAPE SEQUENCE NUMBER   2 OF 4

SCENE/FRAME ID  XXXX-XXXXXXX  FRAME ID XXXXXXXX STRIP ID XXXX

MISSION NUMBER X              REV NO  XXXX       LAUNCH DATE  N/A

EXPOSURE DATE XX XXX XX       DATE RELATIVE TO LAUNCH    DAYS HRS MIN SEC
                                                         XXX  XX  XX  XX

FORMAT CENTER X  XX DEG XX  MIN   NADIR  X XX/DEG   XXMINXX

SUN ELEVATION XX DEG     AZIMUTH   XXX DEG    SPACECRAFT HEADING   XXX DEG

EARTH IMAGE EXPOSURE LEVEL
SHUTTER SETTING/APERTURE

                                   CORRECTION INDICATOR  D

DATE ACQUISITION SITE  G-

           NUMBER OF CHANNELS  4     NUMBER OF SAMPLES/LINE  (PAGE 3)

                                                                                   RET

TO STEP TO NEXT PAGE HIT EOT
TO CANCEL DISPLAY AND LOAD FULL TAPE IMAGE,CHECK BOX FTL
TO CANCEL DISPLAY AND PROCEED TO IMAGE SUBSET SELECTION, CHECK BOW CHD
                                                                                   EOF
                                                                                   EOT
```

Figure 5.4.1-1 ERTSA MSS Bulk Ancillary Data Display

Approved: ______ NASA/DPB ______ PHO

CHD

FTL

UNIVERSAL FORMAT ANCILLARY DATA DISPLAY

COMPUTER SYSTEM ID : CYBER 70 PRODUCTION DATA SYSTEM

TAPE LIBRARY ID :   TAPE NO(S) ON PAGE 3

XX DAY XX MONTH   XX YEAR

TIME OF FIRST SCAN ON THIS TAPE

XX YEAR XX MONTH XX DAY XX MINUTE XX SECOND XXXX TENS/MILLISEC

WORD SIZE OF GENERATING COMPUTER : X BITS

NUMBER OF BITS IN A PICTURE ELEMENT : X

DATA IS : PROCESSED FORM   DATA IS : INTERLEAVED

SENSOR ID :

MISSION NUMBER : X   ORBIT : XX

SITE : XXXX   LINE : X   RUN : X

RET

TO STEP TO NEXT PAGE HIT EOT
TO CANCEL DISPLAY AND LOAD FULL TAPE IMAGE, CHECK BOX FTL
TO CANCEL DISPLAY AND PROCEED TO IMAGE SUBSET SELECTION, CHECK BOX CHD

EOF

EOT

Figure 5.4.1-2 Universal Format Ancillary Data Display

Approved: ________ NASA/DPB ________ PHO

Approved: ______ NASA/DPB ______ PHO

CMD

FTL

MSC MSS ANCILLARY DATA DISPLAY   PAGE 1

TAPE NO(S) :   RUN NUMBER XX

FLIGHT LINE XXXXXXXX XXX X   DATE TIME DAY MNTH YEAR
XXXX XX XX XX

ALTITUDE XXXXX   GROUND HEADING XXXXX

NUMBER OF CHANNELS XX   NUMBER OF SAMPLES/LINE XXXXX

RET

TO STEP TO NEXT HIT EOT
TO CANCEL DISPLAY AND LOAD FULL TAPE IMAGE, CHECK BOX FTL
TO CANCEL DISPLAY AND PROCEED TO IMAGE SUBSET SELECTION, CHECK BOX CMD

EOF

EOT

Figure 5.4.1-3 MSC MSS Ancillary Data Display

Approved: ________ NASA/DPB ________ PHO

LOAD TAPE ANCILLARY DATA DISPLAY   PAGE 2

AVAILABLE CHANNELS DISPLAY

CHANNEL NUMBER	SPECTRAL BAND	CHANNEL NUMBER	SPECTRAL BAND
XX	XXXXXX-XXXXXX	XX	XXXXXX-XXXXXX
XX	XXXXXX-XXXXXX	XX	XXXXXX-XXXXXX

CHD
FLT

RET

TO STEP TO NEXT PAGE HIT EOT
TO CANCEL DISPLAY AND LOAD FULL TAPE IMAGE, CHECK BOX FTL
TO CANCEL DISPLAY AND PROCEED TO IMAGE SUBSET SELECTION, CHECK BOX CHD

EOF
EOT

Figure 5.4.1-4 LOAD Tape Ancillary Data Display - Channels

Approved: ________ NASA/DPB ________ PHO

```
                    LOAD TAPE ANCILLARY DATA DISPLAY  PAGE 3          [CND]
                                                                      [FTL]
TAPE NUMBER XXXXX   FIRST PIXEL     X   LAST PIXEL    XXX




                                                                      [RET]

TO STEP TO NEXT PAGE HIT EOT
TO CANCEL DISPLAY AND LOAD FULL TAPE IMAGE, CHECK BOX FTL
TO CANCEL DISPLAY AND PROCEED TO IMAGE SUBSET SELECTION, CHECK BOX CND
                                                                      [EOF]
                                                                      [EOT]
```

Figure 5.4.1-5 LOAD Tape Ancillary Data Display - Tape

Approved: ________ NASA/DPB ________ PHO

CR
NP

POST-LOAD REPORT

TAPE NUMBER (S)

IMAGE SET ID IMAGE XXX

IMAGE SET CONTENTS

FIRST LINE XXXXXX NUMBER OF LINES XXXXXX

FIRST PIXEL XXXXXX NUMBER OF PIXELS XXXXXX

LINES SKIPPED XX PIXELS SKIPPED XX

CHANNELS SELECTED XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX
XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX

RET

TO CANCEL REPORT POINT AT BOX CR FOR NEW PAGE POINT AT BOX NP

EOF
ECT

Figure 5.4.2-1 Post-Load Report

SECTION 6

IMAGE MANIPULATION AND DISPLAY REQUIREMENTS

TABLE OF CONTENTS

SECTION 6

LIST OF FIGURES

SECTION 6

IMAGE MANIPULATION AND DISPLAY REQUIREMENTS

6.1 INTRODUCTION

The Image Manipulation and Display (IMD) Application will be capable of outputing data to the Landscape TV in up to 64 colors or to the COM microfiche unit. IMD will provide the user the capability to scroll an image, to translate an image, or to zoom in on a portion of an image.

Approved: ____________ NASA/DPB ____________ PHO

6.2 USER INTERFACE REQUIREMENTS

The ERIPS user will have the capability to select the IMD application from the Application Selection Menu after signing on to the system and loading the data necessary for IMD processing. The IMD may be selected to display by user specified image name any loaded or generated image.

Approved: ______________ NASA/DPB ______________ PHO

6.2.1 General Capabilities

The ERIPS user should have the capability to select the IMD Application from any of the applications of the ERIPS without losing the internal data of that application. A RETURN indication on the IMD menu would then return the user to the appropriate position in the application from which he selected the IMD application. Also, the capability will exist to select SCR (Image Scroll), EOF (End-of-Field), EOT (End-of-Transmission), AI (display Available Images Report), BP2 (batch print screen 2), BP3 (batch print screen 3), BP5 (batch print screen 5), BP6 (batch print screen 6), LLT (lat./long. and cursor position table), FLO (field overlay), CI2 (display next channel of image on screen 2), CI3 (same as CI2, but for screen 3), CI5 (same as CI2, but for screen 5), CI6 (same as CI2, but for screen 6), and S64 (paging of menu when using 64 colors to observe all color assignments) on the menu without the use of the keyboard.

Approved: TAP NASA/DPB RWL PHO

6.2.2 IMD Image Definition and Screen Status Menu

An example of the IMD Image Definition and Screen Status Menu for a two eight-color SCREEN configuration is shown in Figure 6.2.2-1. All X's in the figure represent displayed data and the dashed lines represent user input data. The screen status information will be listed in the appropriate column under SCREEN 2, SCREEN 3, SCREEN 5, or SCREEN 6 and will provide the user with information concerning the configuration of the images on each screen. The far right columns containing the dashed lines are for user input data to define the image as he wishes to view it. The CI2, CI3, CI5, and CI6 special functions will provide the user with the capability to display the next-highest numbered channel of the image he has last requested without use of keyboard inputs. The screen number, magnification, boundary definitions, and histogram convention as previously specified by the user will remain in effect.

When operating in the 64 color mode it will be necessary to page the IMD Image Definition and Screen Status Menu to observe color assignments for all 64 colors. This will be accomplished via the S64 immediate action paging box. The menus for this option are shown in Figures 6.2.2-2, 6.2.2-3, 6.2.2-4, and 6.2.2-5. When the 64 color option has been selected either SCREEN 3 column or SCREEN 6 column will contain no information.

Magnification may be positive or negative and will involve repeating or deleting the appropriate pixels and lines. INITIAL LINE and PIXEL may be defaulted and the image will be displayed with the initial line and pixel, even if both are not 1. If initial line and pixel numbers specified begin with a "C", that line and/or pixel value will be the center point of the displayed image. Radiance/level options will use the following:

HXXX – Histogram the portion of the image specified by X, i.e., x = 100 historgram 100 lines.

E – Use the existing gray level translate table.

D – Use the default gray levels: 0 to 255 in 16 equal increments.

C – Classification image.

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IMAGE MANIPULATION AND DISPLAY MENU

SCREEN 2	SCREEN 3	SCREEN 5	SCREEN 6
XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
XX	XX	XX	XX
XX	XX	XX	XX
XXXXX	XXXXX	XXXXX	XXXXX
XXXXX	XXXXX	XXXXX	XXXXX
XXXX	XXXX	XXXX	XXXX
XXX TO XXX	XXX TO XXX	XXX TO XXX	XXX TO XXX
	XXX TO XXX		XXX TO XXX
XXX TO XXX		XXX TO XXX	

SCREEN NO __
IMAGE ID ________
BAND NO __
MAGN __
INIT LIN _____
INIT PIX _____
RAD/LVL _____

G/C LVL 01 ___ TO ___
G/C LVL 02 ___ TO ___
G/C LVL 03 ___ TO ___
G/C LVL 04 ___ TO ___
G/C LVL 05 ___ TO ___
G/C LVL 06 ___ TO ___
G/C LVL 07 ___ TO ___
G/C LVL 08 ___ TO ___
G/C LVL 09 ___ TO ___
G/C LVL 10 ___ TO ___
G/C LVL 11 ___ TO ___
G/C LVL 12 ___ TO ___
G/C LVL 13 ___ TO ___
G/C LVL 14 ___ TO ___
G/C LVL 15 ___ TO ___
G/C LVL 16 ___ TO ___

SCR
AI
BP2
BP3
BP5
BP6
LLT
FLO
CI2
CI3
CI5
CI6
S64
RET
EOF
EOT

Figure 6.2.2-1 Image Manipulation and Display Menu Gray Levels 01-16 (Two 8-color screens.)

Approved: TBP NASA/DPB RMS PHO ______

IMAGE MANIPULATION AND DISPLAY MENU

SCREEN 2	SCREEN 5	SCREEN 6		
XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXX	SCREEN NO. __	SCR
XX	XX	XX	IMAGE ID ________	AI
XX	XX	XX	BAND NO __	BP2
XXXXX	XXXXX	XXXXX	MAGN __	BP3
XXXXX	XXXX	XXXX	INIT LIN ____	BP5
XXXX	XXXX	XXXX	INIT PIX ____	BP6
			RAD/LVL ____	LLT

XXX TO XXX	XXX TO XXX	XXX TO XXX	G/C LVL 01 __ TO __	FLO
			G/C LVL 02 __ TO __	CI2
			G/C LVL 03 __ TO __	CI3
			G/C LVL 04 __ TO __	CI5
			G/C LVL 05 __ TO __	CI6
			G/C LVL 06 __ TO __	S64
			G/C LVL 07 __ TO __	RET
			G/C LVL 08 __ TO __	EOF
			G/C LVL 09 __ TO __	EOT
			G/C LVL 10 __ TO __	
			G/C LVL 11 __ TO __	
			G/C LVL 12 __ TO __	
			G/C LVL 13 __ TO __	
			G/C LVL 14 __ TO __	
			G/C LVL 15 __ TO __	
			G/C LVL 16 __ TO __	
XXX TO XXX	XXX TO XXX	XXX TO XXX		

Figure 6.2.2-2 Image Manipulation and Display Menu Gray/Color Levels 01-16

Approved: ________ NASA/DPB ________ PHO

```
                         IMAGE MANIPULATION AND DISPLAY MENU                          SCR
SCREEN 2                        SCREEN 5         SCREEN 6
                                                                  SCREEN NO. __       AI
XXXXXXXXXXXX                    XXXXXXXXXXXX     XXXXXXXXXXX      IMAGE ID ________
XX                              XX               XX               BAND NO. __         BP2
XX                              XX               XX               MAGN __
XXXXX                           XXXXX            XXXXX            INIT LIN ____       BP3
XXXXX                           XXXXX            XXXXX            INIT PIX ____
XXXX                            XXXX             XXXX             RAD/LVL ____        BP5

XXX TO XXX                      XXX TO XXX       XXX TO XXX       G/C LVL 17 __ TO __ BP6
                                                                  G/C LVL 18 __ TO __
                                                                  G/C LVL 19 __ TO __ LLT
                                                                  G/C LVL 20 __ TO __
                                                                  G/C LVL 21 __ TO __ FLO
                                                                  G/C LVL 22 __ TO __
                                                                  G/C LVL 23 __ TO __ CI2
                                                                  G/C LVL 24 __ TO __
                                                                  G/C LVL 25 __ TO __ CI3
                                                                  G/C LVL 26 __ TO __
                                                                  G/C LVL 27 __ TO __ CI5
                                                                  G/C LVL 28 __ TO __
                                                                  G/C LVL 29 __ TO __ CI6
                                                                  G/C LVL 30 __ TO __
                                                                  G/C LVL 31 __ TO __ S64
XXX TO XXX                      XXX TO XXX       XXX TO XXX       G/C LVL 32 __ TO __

                                                                                      RET


                                                                                      EOF

                                                                                      EOT
```

Figure 6.2.2-3 Image Manipulation and Display Menu Gray/Color Levels 17-32

Approved: ______ NASA/DPB ______ PHO

```
                         IMAGE MANIPULATION AND DISPLAY MENU                  SCR
SCREEN 2                        SCREEN 5       SCREEN 6
                                                           SCREEN NO. __      AI
XXXXXXXXXXXX                    XXXXXXXXXXXX   XXXXXXXXXXX IMAGE ID ______
XX                              XX             XX          BAND NO. __        BP2
XX                              XX             XX          MAGN __
XXXXX                           XXXXX          XXXXX       INIT LIN ____      BP3
XXXXX                           XXXXX          XXXXX       INIT PIX ____
XXXX                            XXXX           XXXX        RAD/LVL ____       BP5

                                                                              BP6
XXX TO XXX                      XXX TO XXX     XXX TO XXX  G/C LVL 33 __ TO __
                                                           G/C LVL 34 __ TO __ LLT
                                                           G/C LVL 35 __ TO __
                                                           G/C LVL 36 __ TO __ FLO
                                                           G/C LVL 37 __ TO __
                                                           G/C LVL 38 __ TO __ CI2
                                                           G/C LVL 39 __ TO __
                                                           G/C LVL 40 __ TO __ CI3
                                                           G/C LVL 41 __ TO __
                                                           G/C LVL 42 __ TO __ CI5
                                                           G/C LVL 43 __ TO __
                                                           G/C LVL 44 __ TO __ CI6
                                                           G/C LVL 45 __ TO __
                                                           G/C LVL 46 __ TO __ S64
                                                           G/C LVL 47 __ TO __
XXX TO XXX                      XXX TO XXX     XXX TO XXX  G/C LVL 48 __ TO __

                                                                              RET

                                                                              EOF

                                                                              EOT
```

Figure 6.2.2-4 Image Manipulation and Display Menu Gray/Color Levels 33-48

PHO-TR514
Change 5
11 March 1975

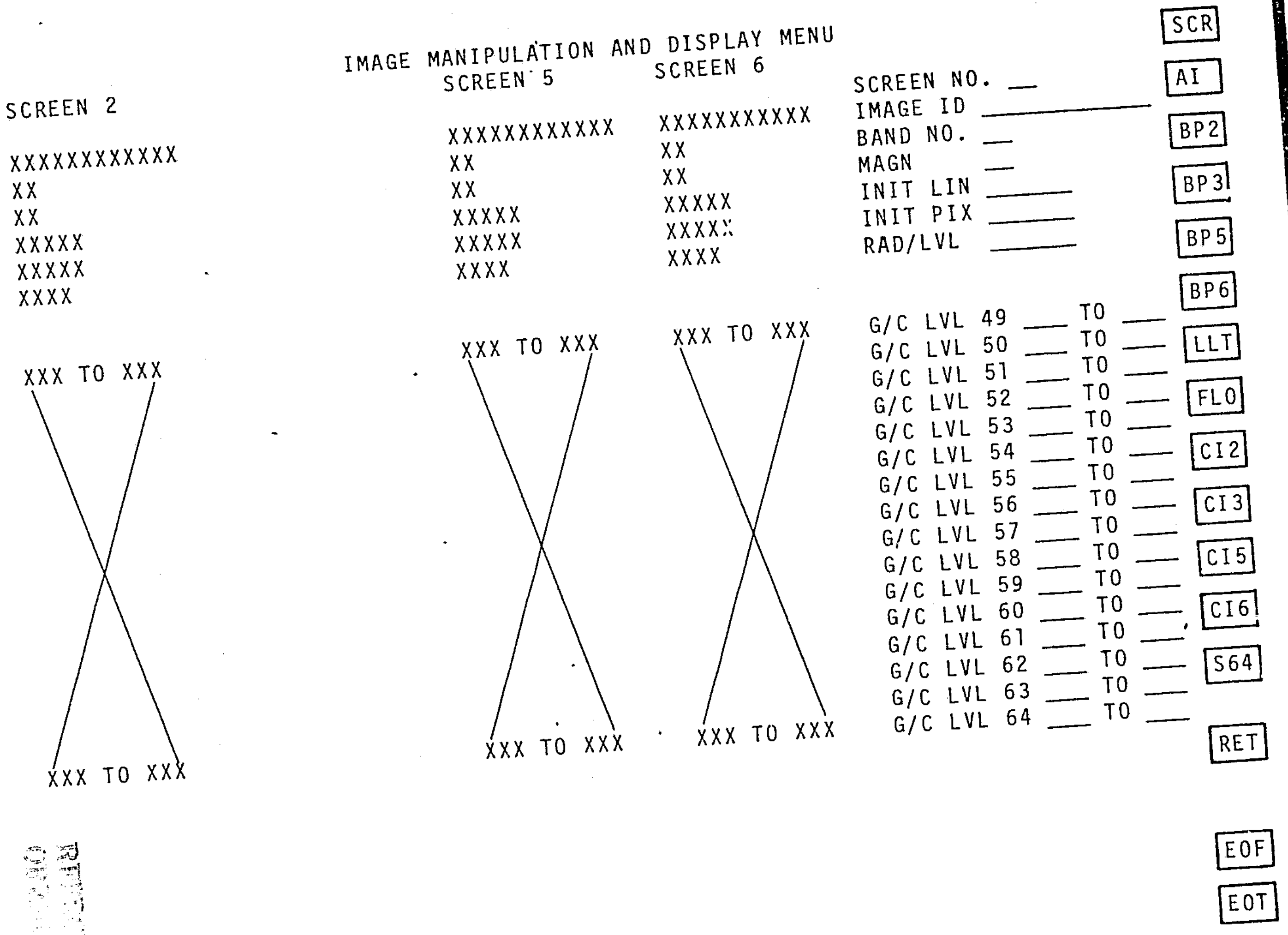

Figure 6.2.2-5 Image Manipulation and Display Menu Gray/Color Levels 49-64

Approved: ____ NASA/DPB ____ PHO

6.3 GRAY LEVEL AND COLOR DETERMINATION

6.3.1 Gray Level Images

Gray lèvel images will be displayed in a maximum of 16 levels of gray unless specified to be less by the user. Default over the 16 levels of gray will be to divide the radiance range (256) by 16 for the gray level assignments.

Approved: TAP NASA/DPB RWS PHO

6.3.2 Color Images

Color images will be displayed in a maximum of 64 colors (or 8 colors if only 8 available) unless specified to be less by the user. Default over the 64 colors will be to divide he radiance range (256) by 64 for the color assignment.

Approved: ______ NASA/DPB ______ PHO

6.3.3 Gray/Color Distribution

Each resolution element of each channel will have a range of possible values depending upon the relative radiance of the particular element in that band. The distribution of the gray levels or colors corresponding to those possible numerical values will be determined in one of the following user specified methods.

A. Divided equally over the range of possible values.

B. User specified by a prior knowledge of the data being processed.

C. Computation of a set of gray levels or colors using the maximum and minimum data values and the distribution of the intermediate data values.

Approved: ______________ NASA/DPB ______________ PHO

6.4 OUTPUT

In addition to the screen status report available to the user as described in Paragraph 6.2.2, the user may select a report that will list the images that are available for display. This report, as shown in Figure 6.4-1, will provide the image name, the dimensions of the image by number of bands, first line, number of lines and skip factor, first pixel, number of pixels and skip factor, and finally an image description.

The LLT special function will provide the user with the menu shown in Figure 6.4-2. The user will be able to specify points on the image screen via cursor and observe on this menu/report the line/column values for the points. In the event the image has been pre-registered to a UTM grid, the same operation (or the specification of line/column values on the menu) will provide a display of the geographic latitude and longitude of the points.

Approved: ______________ NASA/DPB ______________ PHO

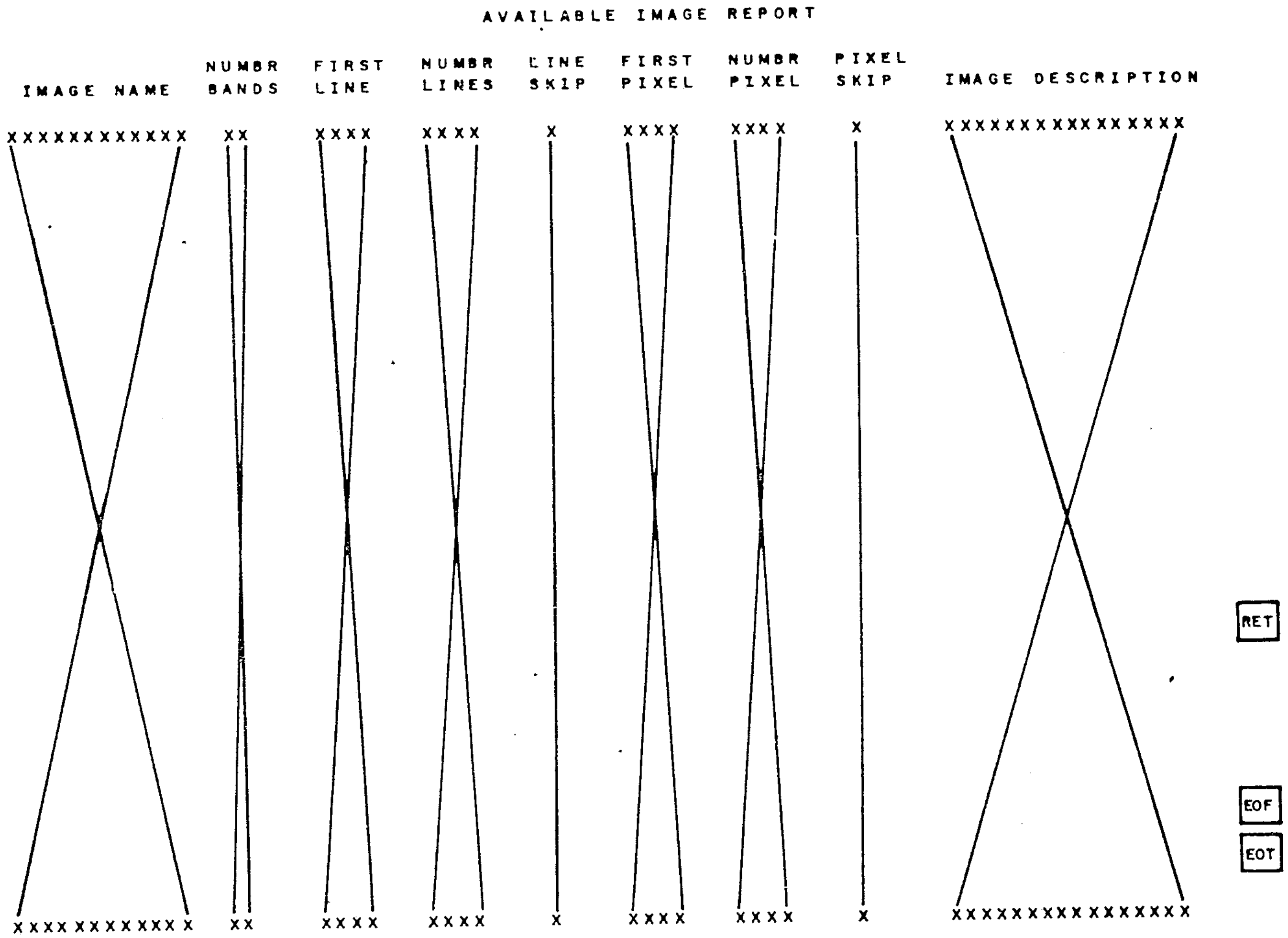

Figure 6.4-1 Available Images Report

IMD LATITUDE / LONGITUDE TABLE

SCR

IMAGE NAME □________

ENTER POINTS:
  VIA CURSOR – CURSOR POINTS THEN EOF, EOT.
    OR
  VIA KEYBOARD – EOF THEN ENTER POINTS, EOT.

POINT	LINE	PIXEL	LINE	PIXEL	LATITUDE	LONGITUDE
1	____	____	0	0	00:00:00:00N	000:00:00:00E
2	____	____				
3	____	____				
4	____	____				
5	____	____				
6	____	____				
7	____	____				
8	____	____				
9	____	____				
10	____	____				
11	____	____				
12	____	____				
13	____	____				
14	____	____				
15	____	____				
16	____	____				
17	____	____				
18	____	____				
19	____	____				
20	____	____				
21	____	____				
22	____	____				
23	____	____				
24	____	____				
25	____	____				

RET

EOF

EOT

Figure 6.4-2 Latitude/Longitude and Cursor Position Indicator Table

Approved: ________ NASA/DPB ________ PHO

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SECTION 7

IMAGE REGISTRATION

7.1 INTRODUCTION

7.1.1 General

Image Registration will provide two capabilities: (1) The capability to conform an "input image" of a given scene to a Reference Image of the same scene and (2) the capability to map an input image onto a predefined latitude/longitude grid.

7.1.2 Program Description

The basic program operation will be similar for either the image/grid or the image/image options, the chief difference being in the way the user identifies "control points." For image/grid, the user will be presented with a gray-scale TV image of a selected image. With a pointer, he will designate some number of geographic features and provide the computer with a point identification (ID) number, latitude, and longitude for each point. For image/image, the user will identify one of two loaded images as the Reference Image. The other will then be the Input Image. (The latter will be "mapped" to conform to the former). The user will be provided two simultaneous displays one of the reference image, the other of the input image (any combination of the two gray-scale and one color monitors may be selected). The user will select (by means described in Paragraph 7.2) a point on each image, which he has determined to be common to both images, and input an ID number for the point pair. He will then repeat the process for the desired number of points, and command the computer to calculate a "fit." A visible point marker will be provided and will remain on the screen until IMD or scroll are exercised again. Following the identification of points, the computer processing requirements for image/grid and image/image are similar. The program will compare the image position of each input point to the corresponding reference point (which in the case of image/grid is just a coordinate), and will use the "errors" to calculate "least-squares" coefficients for a bivariant Nth-order polynominal ($N \leq 6$, determined by operator selection).

This polynominal will completely specify a mapping transformation, but at this point, the actual transformation will not have occurred. Evaluation parameters associated with the least-squares fit will be generated for display (as defined in Paragraph 7.4) to the user. Based on these, he may choose to repeat or modify the point selection. When he is satisfied with the data, he can then allow the actual mapping to take place, at which time the appropriate output image will be generated. There will be the capability to create a "Difference Image" from two co-registered input images.

Approved: [signature] NASA/DPB [signature] PHO

7.2 USER INTERFACE REQUIREMENTS

7.2.1 General

The initial process of generating, positioning, scaling, etc., of the images will normally have been accomplished via the LOAD and IMAGE MANIPULATION and DISPLAY (IMD) applications.

All menus presented to the user in the image registration application will include capabilities: to scroll the image(s), to select the image manipulation and display application, and via error recover logic to allow unloading and scratching from disk, all without exiting from the image registration application. Also, the capability will exist to indicate the EOF (end-of-field) and EOT (end-of-transmission) on all menus without use of the keyboard. The user may return to the previous menu by indicating a return on any of the menus in this application.

All displayed images in this application will include on the overlay a position indicator (line & column) of the upper left hand corner, the lower right hand corner, and the cursor. The corner positions will be updated as the image(s) is scrolled but the cursor position will be updated only when the pointer is activated.

7.2.2 Processor Selection

Upon entering the REGISTRATION application the user will be presented with an option menu (see Figure 7.2.2-1 with which he can interact with minimum use of the keyboard. The menu will include:

- Choice of image/grid or image/image processors.
- Manual entry option for mapping polynominals. The coefficients may be entered in floating point or scientific notation. The polynomial will be applied to the image such that all of the input points will be transformed onto the output, with no "loss" of pixels (assuming no translation term is input).
- Also, a capability will exist to perform a "two-pass" mapping. The first pass through Registration will correct for gross 1st Order effects (primarily rotation and translation). The resulting "pre-corrected" image will then be the Input Image for more detailed point selection and polynominal calculation. This method for removing large rotations will result in reduced time to do the mapping, and will provide the operator with a more favorably oriented display for precise point location. This will be accomplished by selecting "1st Order" on the Polynominal Generation Select Menu (Paragraph 7.2.7) and proceeding through the application, including menu Point Shift Image Definition Menu Paragraph 7.2.8, then repeating with the order of polynominal desired. Selecting an order higher than the 1st Order will generate an error message if large 1st Order effects are present.

Upon operator completion of this menu, a menu associated with his selected option will appear (Paragraph 7.2.3, 7.2.4, or 7.2.5 as appropriate).

Approved: [signature] NASA/DPB RNS PHO

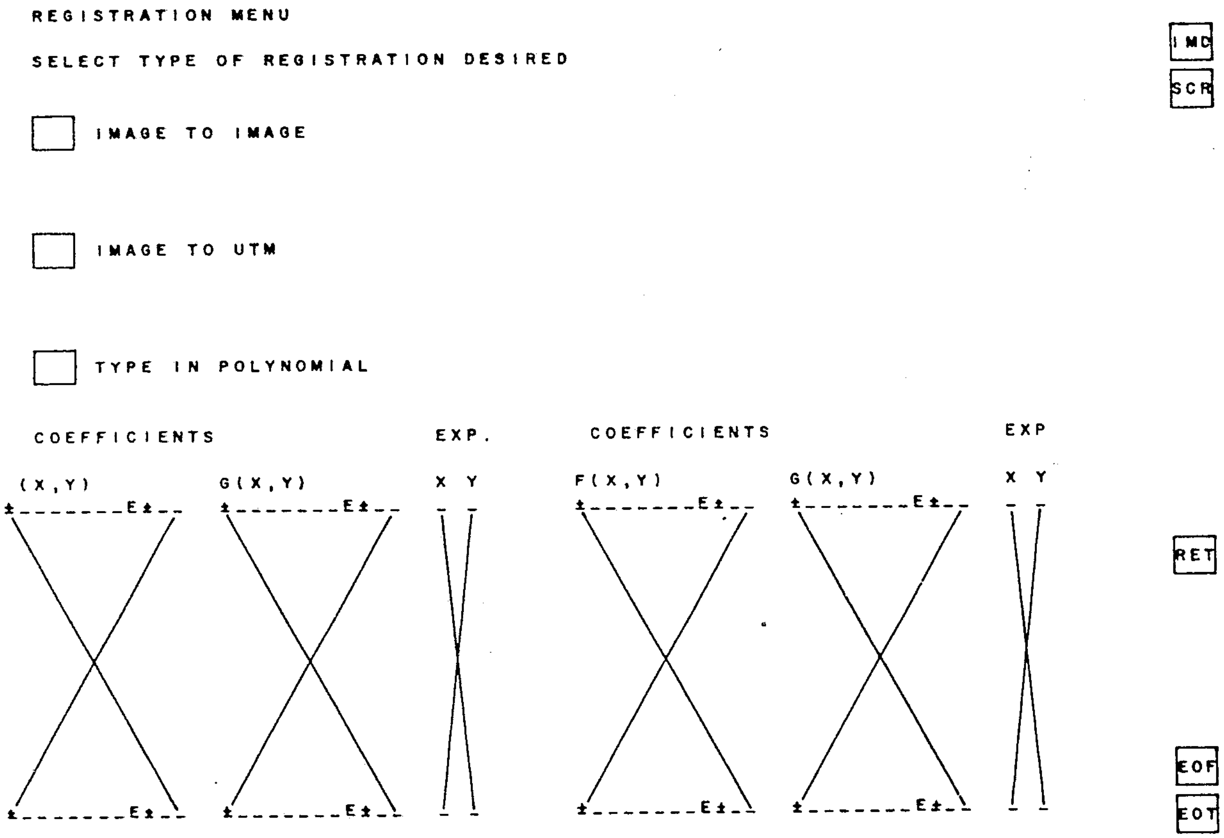

Figure 7.2.2-1 Registration Menu

7.2.3 (Image/Grid) Output Image Boundary Definition

The purpose of this menu (see Figure 7.2.3-1) is to define the UTM boundaries for the desired mapping, and to identify (by image name) the input image so that the system can define the extent and scale of the output image. The required inputs are image name, most north latitude*, most south latitude, most east longitude, and most west longitude*.

7.2.4 (Image/Grid) Output Granularity Select

The purpose of this menu (see Figure 7.2.4-1) is to arrive at an optimum output granularity (i.e., the ground spot size represented by a single output pixel). A granularity which is much finer than that of the input image is wasteful of CPU time. The program will automatically select from a standard table of available granularities (2, 4, 40 and 80 meters) the largest value which is finer than the input image granularity. If the operator desires, he may manually (by Grafacon input) select any other value from the table. If the selected value would result in an output image of greater than 10^7 elements, an error indication will be provided.

7.2.5 (Image/Grid) Image to UTM Point Selection/Identification

This menu (see Figure 7.2.5-1) will provide two main options: (1) Add new point, and (2) "Prepare to generate mapping polynomial." Within the "Add new point" option, there will be the option to designate the next point to be selected as "active" or "reserve," and spaces for entry of point LAT/LONG* and ID code. An entry of EOT on this option will result in incorporation of the selected point into the point list. An entry of EOT on the "Prepare to generate" option will release the display and bring up the Polynominal Generation Select Menu. Up to 150 points may be entered.

There will be provided a capability to pre-load a point ID versus LAT/LONG catalogue such that the operator may default on LAT/LONG type-in and enter only the appropriate point ID. Detailed implementation will be provided at a later date.

7.2.6 (Image/Image) Image to Image Point Selection/Identification

This menu (see Figure 7.2.6-1) will be esentially identical to the corresponding Image/UTM Menu (Paragraph 7.2.5) the exception being that there will be no LAT/LONG entry.

This menu must operate in conjunction with two image screens. The operator must select control points in pairs, in the order (reference/input) indicated on the menu. The points will be stored in the order selected. A visible point "marker" will remain on the image screen(s) until "SCR" or "IMD" are selected. If the operator wishes to relocate a point prior to entering "EOT" he may do so by backspacing to the appropriate step of the menu and starting over. After "EOT" is entered, points must be deleted or corrected by proceeding to the "Point Evaluation Display" (see Paragraph 7.4.4.1).

*The convention for entering LAT/LONG will be:

- LAT - 1st digit, N or S; two places for degrees; two places for minutes; three places for seconds to the 1/10 sec.
- LONG - 1st digit E or W; three places for degrees (0 to 180); otherwise same as LAT.

Approved: [signature] NASA/DPB [signature] PHO

```
                                                              [IMD]
                                                              [SCR]
                     REGISTRATION MENU

IMAGE TO UTM - OUTPUT IMAGE BOUNDARY DEFINITION

   TYPE IN THE UTM BOUNDARIES OF THE AREA TO BE MAPPED
   IN THE OUTPUT IMAGE

      MOST NORTH LATITUDE   ___ __ ___._

      MOST SOUTH LATITUDE   ___ __ ___._

      MOST WEST LONGITUDE   ____ __ ___._

      MOST EAST LONGITUDE   ____ __ ___._

   TYPE IN NAME OF IMAGE TO BE REGISTERED   ____________
                                                              [RET]



                                                              [EOF]
                                                              [EOT]
```

Figure 7.2.3-1 Output Image Boundary Definition

REGISTRATION MENU

OUTPUT IMAGE GRANULARITY SELECTION

THE BOX BELOW WHICH IS CHECKED CORRESPONDS TO THE RECOMMENDED VALUE FOR GRANULARITY OF THE OUTPUT IMAGE. TO OVERRIDE THIS SELECT ANY OTHER BOX. IF NO BOX IS SELECTED THE RECOMMENDED VALUE WILL BE USED.

☐ 2 METERS

☐ 4 METERS

☐ 40 METERS

☐ 80 METERS

[IMD] [SCR] [RET] [EOF] [EOT]

Figure 7.2.4-1 Output Granularity Select

```
                    REGISTRATION MENU                          IMD
                                                               BCR
IMAGE TO UTM POINT SELECTION/IDENTIFICATION

[ ] ADD NEW POINT        [ ]ACTIVE

                         [ ]RESERVE

  1.POINT TO LOCATION ON IMAGE SCREEN.HIT SCREEN I.D.SWITCH.
  2.TYPE IN LATITUDE AND LONGITUDE
    LAT ___ __ __._        LONG ____ __ __._
  3.TYPE IN POINT I.D.                _______
    ENTER EOT ON THIS MENU
                                                               RET
[ ] PREPARE TO GENERATE MAPPING POLYNOMIAL

    ENTER EOT ON THIS MENU

                                                               EOF
                                                               EOT
```

Figure 7.2.5-1 Image to UTM Point Selection/Identification

Approved: ________ NASA/DPB ________ PHO

REGISTRATION MENU

IMAGE TO IMAGE POINT SELECTION / IDENTIFICATION

☐ ADD NEW POINT ☐ ACTIVE

☐ RESERVE

1. POINT TO LOCATION ON REFERENCE IMAGE SCREEN. HIT SCREEN I.D.

2. POINT TO LOCATION ON INPUT IMAGE SCREEN. HIT SCREEN I.D.

3. TYPE IN POINT.I.D. -------

ENTER EOT ON THIS MENU

☐ PREPARE TO GENERATE MAPPING POLYNOMIAL

ENTER EOT ON THIS MENU

IMD
SCR
RET
EOF
EOT

Figure 7.2.6-1 Image to Image Point Selection/Identification

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7.2.7 Polynominal Generation Select Menu

This menu (Figure 7.2.7-1) will allow the selection of the order of the mapping polynominal, from 1st Order through 6th Order. When this has been done the operator can enter the command (via Grafacon input) to compute the mapping polynominal corresponding to the order specified.

Following the computation of at least one mapping polynominal, the displays selectable from the Polynominal Evaluation/Correction Menu (Paragraph 7.2.10) will be available.

7.2.8 Point Shift Image Definition Menu (Figure 7.2.8-1)

This is a required input to the point shift routine. The user will type in the input image name (this is to allow for the case where the user loads an input image and a predetermined polynominal-by-passing the usual point selection process), and name the output image. Upon entry of "EOT", the program will proceed to map the image. During mapping of the image, the user will be informed of the mapping progress.

7.2.9 Mapping Polynominal Evaluation/Correction Menu (Figure 7.2.9-1)

This menu will automatically be displayed following the release of any of the Registration program displays. It will provide for graphacon selection of any of the following options:

- Point evaluation display.
- Polynominal error vector display.
- Mapping movement vector display.
- Run summary display.
- Transform image with current polynominal (will transfer to the Point Shift Image Definition Menu).
- Add more points (will transfer to appropriate Point Selection menu).
- Generate new polynominal with current point list (will transfer to Polynominal Generation Select Menu).
- Post-Map Comments Menu.

7.2.10 Post-Mapping Comments Menu (Figure 7.2.10-1)

This will allow the user to type in any comments or annotations he wishes to be recorded on the output image tape. A user-input box will be provided to allow the user to return to the MAPPING POLYNOMIAL EVALUATION/CORRECTION MENU with his last working data (point list, polynomials, etc.) still intact. The user-entered comments will be recorded on the unload tape such that they will appear as header information when the tape is reloaded onto ERIPS.

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IMD

SCR

REGISTRATION MENU

POLYNOMIAL GENERATION SELECT

COMPUTE NEW MAPPING POLYNOMIAL

SELECT ORDER OF FIT

☐	ONE	4 ACTIVE POINTS REQUIRED
☐	TWO	7 ACTIVE POINTS REQUIRED
☐	THREE	11 ACTIVE POINTS REQUIRED
☐	FOUR	16 ACTIVE POINTS REQUIRED
☐	FIVE	22 ACTIVE POINTS REQUIRED
☐	SIX	29 ACTIVE POINTS REQUIRED

RET

EOF

EOT

Figure 7.2.7-1 Polynomial Generation Select Menu

Approved: ______ NASA/DPB ______ PHO

REGISTRATION MENU

POINT SHIFT

TYPE IN THE FOLLOWING:

1.NAME OF IMAGE TO BE REGISTERED ____________

2.NAME TO BE ASSIGNED TO OUTPUT IMAGE ____________

SPECIFY WHICH CHANNELS TO BE REGISTERED

☐ ALL

OR: INDICATE SUBSET

1	2	3	4	5	6	7	8	9	10	11	12
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
13	14	15	16	17	18	19	20	21	22	23	24
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

IMD

SCR

RET

EOF

EOT

Figure 7.2.8-1 Point Shift Image Definition Menu

Approved: ____ NASA/DPB ____ PHO

IMD

SCR

REGISTRATION MENU

MAPPING POLYNOMIAL EVALUATION/CORRECTION

SELECT ONE OF THE FOLLOWING OPTIONS

☐ POINT EVALUATION DISPLAY

☐ POLYNOMIAL ERROR VECTOR DISPLAY

☐ MAPPING MOVEMENT VECTOR DISPLAY

☐ RUN SUMMARY DISPLAY

☐ TRANSFORM IMAGE WITH CURRENT POLYNOMIAL

RET

☐ ADD MORE POINTS

☐ GENERATE NEW POLYNOMIAL WITH CURRENT POINT LIST

EOF

EOT

Figure 7.2.9-1 Mapping Polynomial Evaluation/Correction

Approved: ________ NASA/DPB ________ PHIO

Approved: ______ NASA/DPB ______ PHO

IMD

SCR

REGISTRATION MENU

USER COMMENTS ENTRY

SELECT ONE OR BOTH OF THE FOLLOWING OPTIONS

☐ USER COMMENTS TO BE ENTERED.
(MAY TYPE IN UP TO 400 CHARACTERS)

RET

☐ ANOTHER IMAGE IS TO BE PROCESSED

EOF

EOT

Figure 7.2.10-1 Post-Mapping "Comments" Menu

7.3 PROCESSING REQUIREMENTS

The equations for the generation of the mapping polynominals and for the assignment of output intensity values will be as document:d in MSC Internal Note No. 72-FM-119, Da:ed May 18, 1972.

The image registration program shall accept as input any of those image sources and formats specified for the ERIPS LOAD application (see Section 5), with the following limitations:

Maximum image width = 1000 points

*Maximum image area = 10^7 points

*This may be for any (length) X (width), provided (width) $\leq 10^3$.

For the input image to reference image option, the maxim applies to each of the two input images.

If the input image contains more than the maximum allowable points, the LOAD options may be exercised (e.g., skip lines or pixels, load partial image, etc.) to achieve the allowabie number.

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7.4 OUTPUTS

7.4.1 General

This section describes the outputs of the Registration application in the areas of imagery, graphic data and digital data. The imagery displays will appear on the imagery television screen in 16 levels of gray and/or on the color television screen, while the graphic and digital data will appear on the conversational television screen in black & white. All reports will be made available for display as requested by the user. The user will also have the option of requesting that the data be printed. In addition, all reports will be available for retrieval upon request under the following conditions:

A. The user has not exited "REGISTRATION"

B. New data has not been requested by the user; i. e., if a new polynominal has been generated, the display parameters corresponding to the last polynominal will not be available (exception: The Run Summary Display will save certain parameters corresponding to previous polynominals).

7.4.2 Imagery

7.4.2.1 Output Image to Tape

The "output" image, i.e., the result of the registration process will be output to tape upon user command. The "granularity" of the output image will be the same as that of the reference image in the case of image-to-image and as specified by the user for the image-to-UTM case. Each pixel of a UTM-Rectified output tape will be uniquely and directly convertible to LAT/LONG coordinates using only that data contained on the tape. In addition, a tape "header report" will provide the user with the image name, the LAT/LONG boundaries, and the pixel size used to generate the image.

7.4.2.2 Output Image to Video

The user will be able to view the output image on any of the three image screens, consistent with the capabilities of the IMD application. In addition, for the UTM output, a visual indication of lattitude/longitude will be provided on the image.

7.4.2.3 Output Image to Microfiche

The software will drive the microfiche interface consistent with the associated ERIPS hardware specifications.

7.4.3 Graphic Data

The following graphic displays will be provided.

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7.4.3.1 Polynominal Error Vector Display (Figure 7.4.3-1)

This display will consist of arrow-like vector symbols originating from the positions of each of the input image control points, and equal to the difference between the "input error" (as indicated by operator point ID inputs) and the "smoothed" error as calculated by the polynominal.

7.4.3.2 Mapping Movement Vector Display (Figure 7.4.3-2)

This display will consist of arrow-like vector symbols originating from each of 16 uniformly distributed (over the input image) points, indicating the direction and distance (appropriate scaling TBD) that the point would have to be moved in order to generate the output image.

7.4.4 Digital Data

The following digital displays will be provided.

7.4.4.1 Image/Image Polynominal Evaluation Display (Figure 7.4.4-1)

If the Image/Image Option is being exercised, the following parameters will be on the display:

- Header Information - Run number, Display page number.
- Column 1 - List of 7-character point-pair ID's in order of entry.
- Column 2 - Input line/pixel coordinate of selected point.
- Column 3 - Reference line/pixel coordinate of selected point.
- Column 4 - Residuals ΔX, ΔY, and $R = \Delta X^2 + \Delta Y^2$ in units of input pixels.
- Column 5 - "IN FIT;" an asterisk (*) will indicate point is active.
- Column 6 - Active/Reserve/Delete/Correct (ARDC) selector. This will consist of a four-character column. The operator will have interactive (grafacon) control to change any point pair from active to reserve or vice versa.

  He may also delete a point pair (by indicating "D") or choose to "correct" either point of a point pair. The latter is accomplished by indicating "C", and redesignating the appropriate point. The new point coordinates will then appear, but the polynomial parameters will remain the same until the option to generate a new polynomial is exercised.

Approved: ____ NASA/DPB ____ PHO

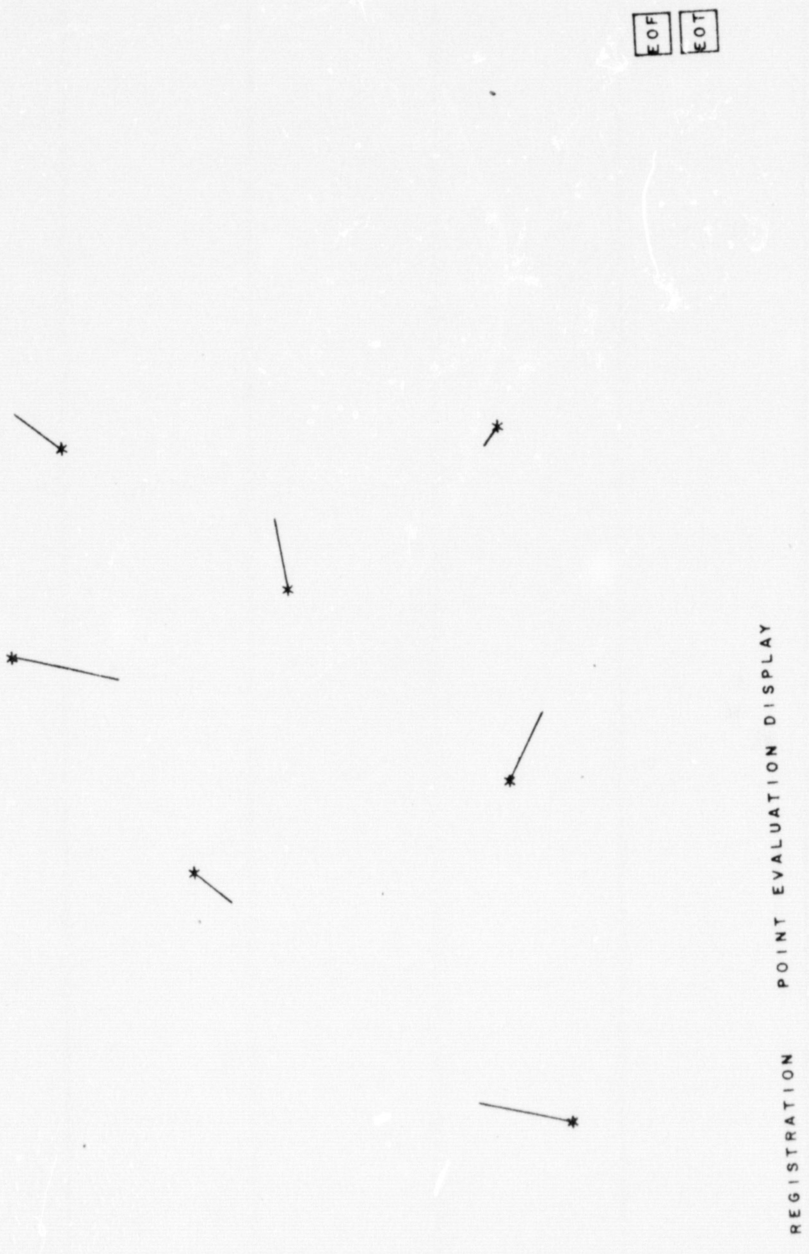

Figure 7.4.3-1 Polynomial Error Vector Display

Approved: ________________ NASA/DPB RMS ________________ PHO

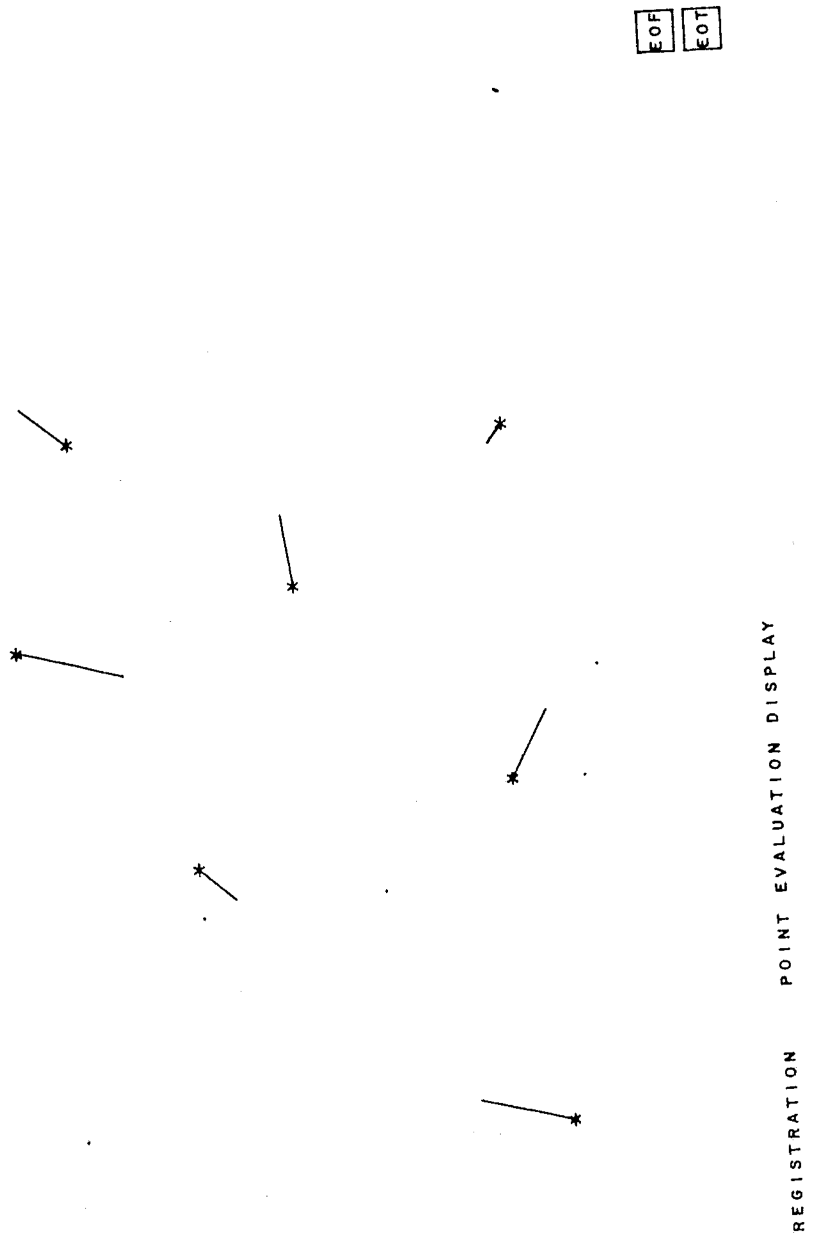

Figure 7.4.3-1 Polynomial Error Vector Display

Approved: ______________________ NASA/DPB ______________________ PHO

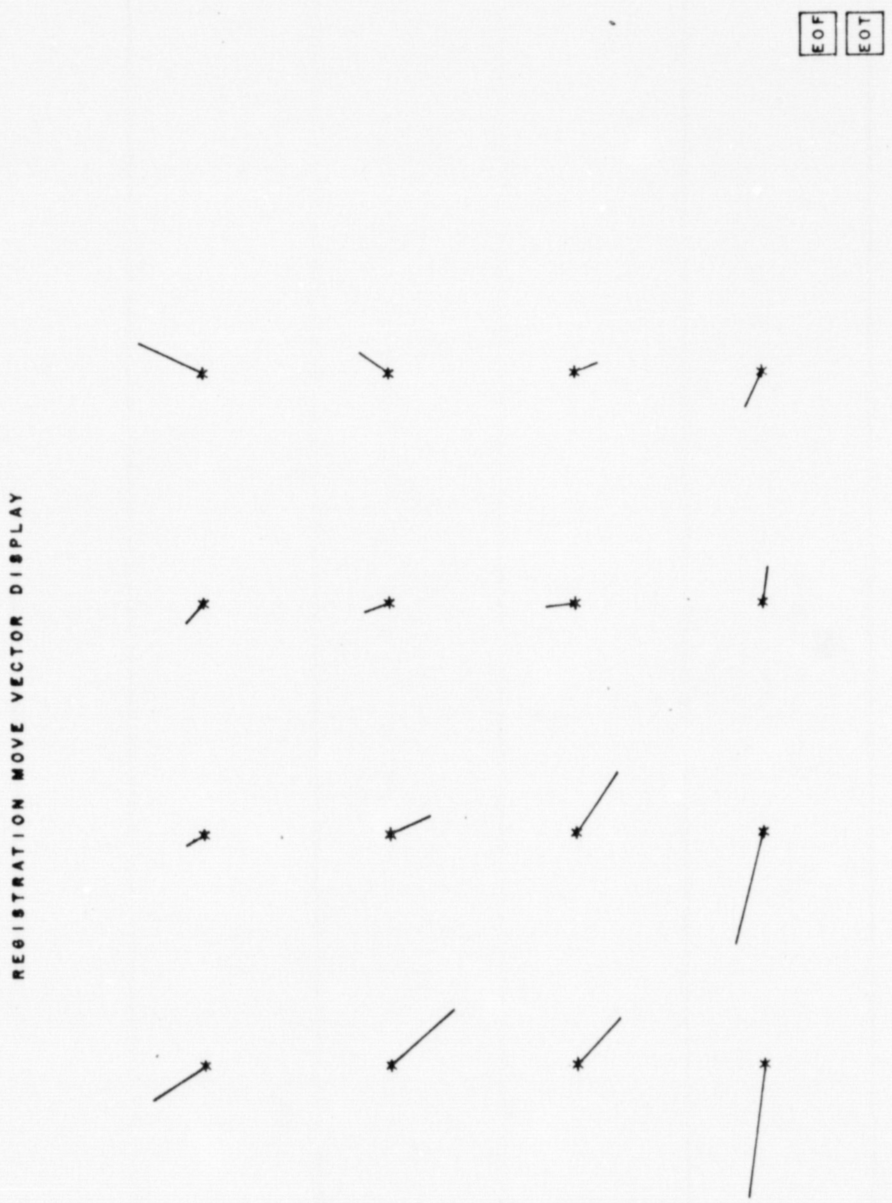

Figure 7.4.3-2 Mapping Movement Vector Display

Approved: ______ 2K ______ NASA/DPB ______ RWS ______ PHO

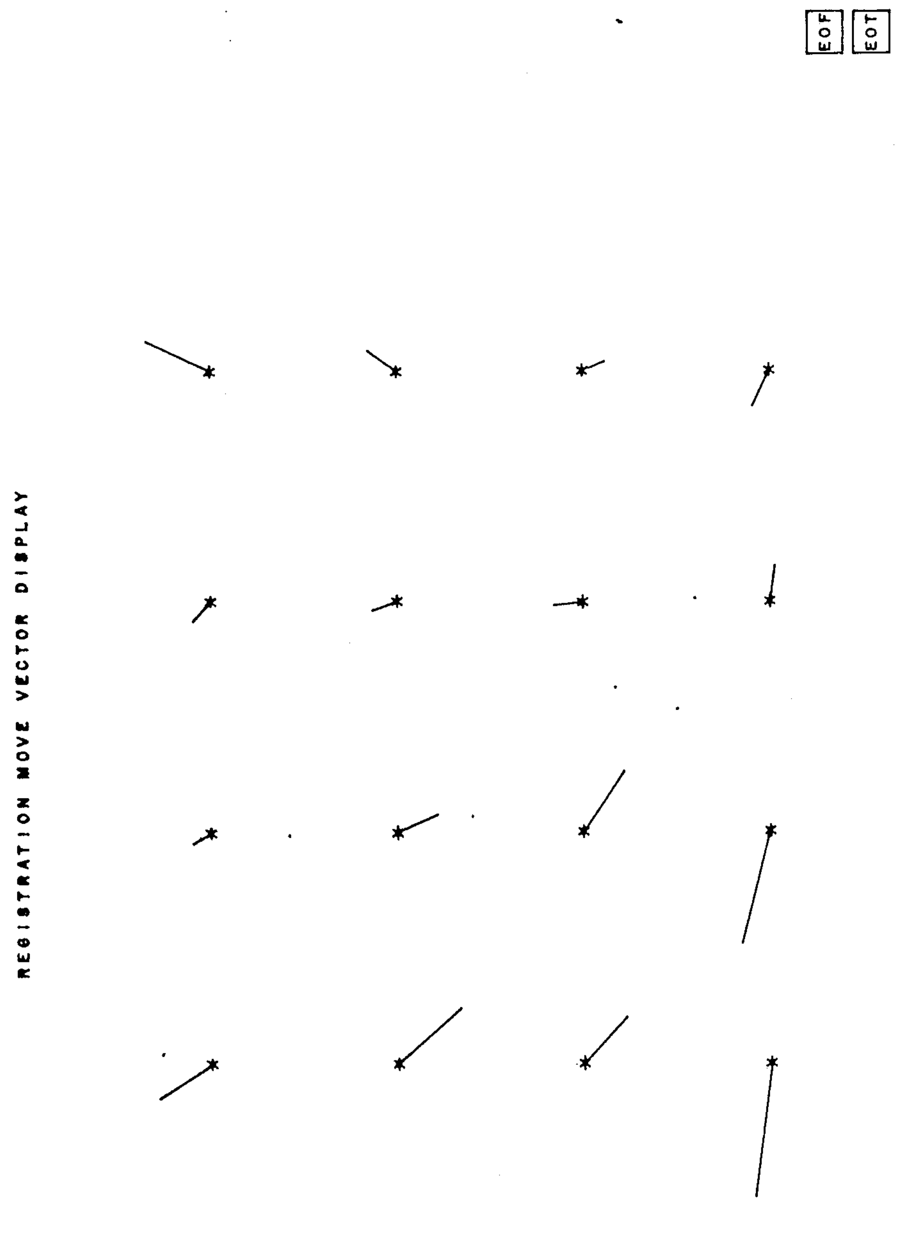

Figure 7.4.3-2 Mapping Movement Vector Display

Approved: ~~Z~~K NASA/DPB RWS PHO

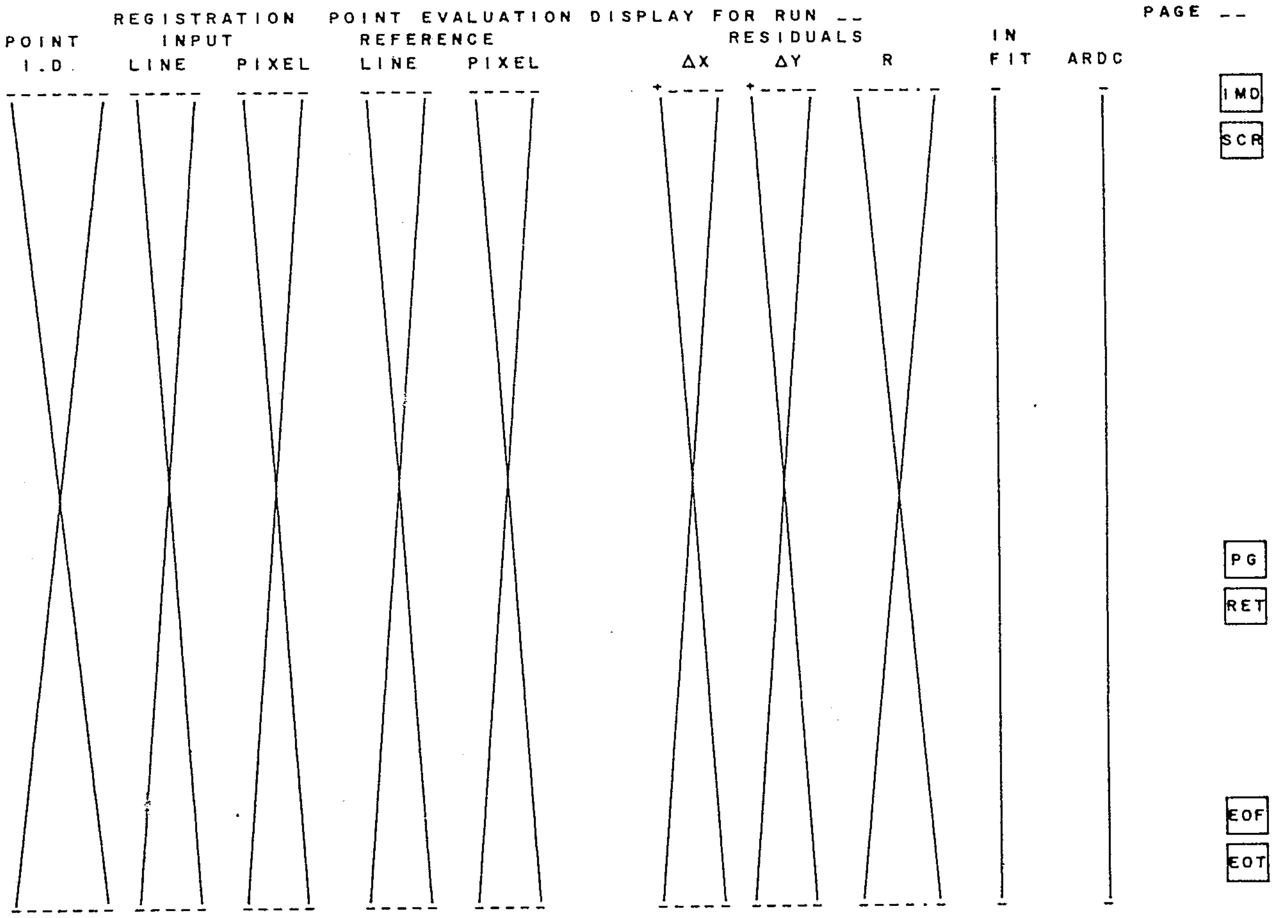

Figure 7.4.4-1 Image/Image Polynomial Evaluation Display

Approved: ________ NASA/DPB ________ PHO

7.4.4.2 Image/Grid Polynomial Evaluation Display (Figure 7.4.4-2)

If the IMAGE/UTM function is being exercised, the display will be the same as Paragraph 7.4.4.1 with the following exceptions:

- Column two will be the reference LAT/LONG*.
- A manual entry option will be provided to type in a new LAT/LONG* when the "Correct" function is being used, without having to interact with the image screen.

7.4.4.3 Run Summary Display (Figure 7.4.4.3)

There will be a column on this display for each "run", i.e., each time a "new" polynomial calculation was ordered. Within each column, there will be displayed:

- The run ID (consecutive, 1 through N)
- The order of the polynomial
- The number of active points
- The mean residual of the active points
- The RMS of the active point residuals
- The maximum residual of the active points
- A repeat of the above for the reserve points.

At the bottom of each page will be displayed the polynomial expression calculated for any run selected by the operator. An option will be provided to replace the "current" polynomial with any of the other runs.

*Because of a current system peculiarity, the format for LAT/LONG will be different on "DISPLAYS" rather than on "MENUS" (see Paragraph 7.2.5). For the displays the direction (N, S, E, W) will appear on the last digit rather than the first. Also, when using the "Correct" Function, LAT/LONG may only be input to the nearest second, although they are displayed to the 1/10 sec.

Approved: ______ NASA/DPB ______ PHO

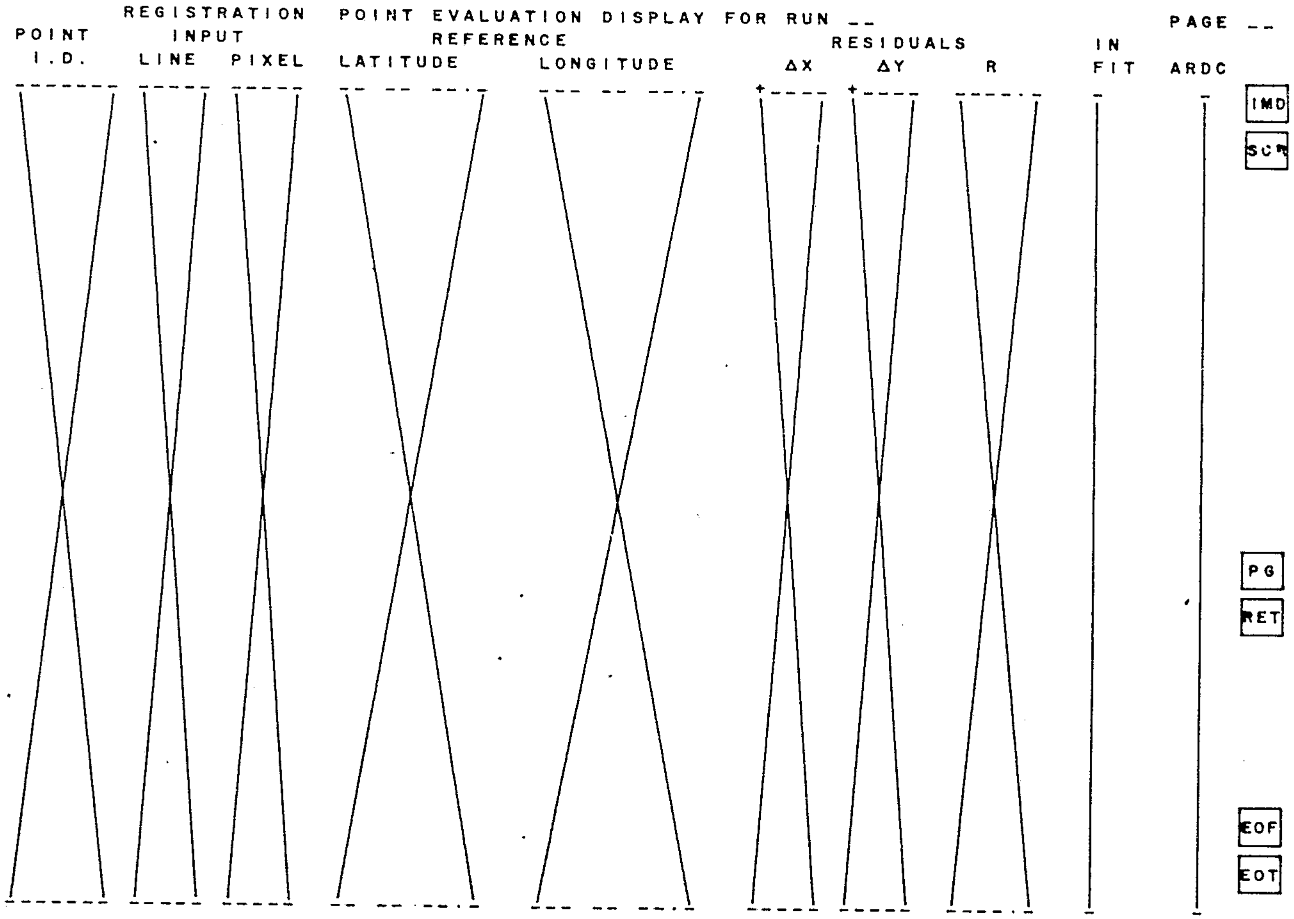

Figure 7.4.4-2 Image/Grid Polynomial Evaluation Display

Approved: ________ NASA/DPB ________ PHO

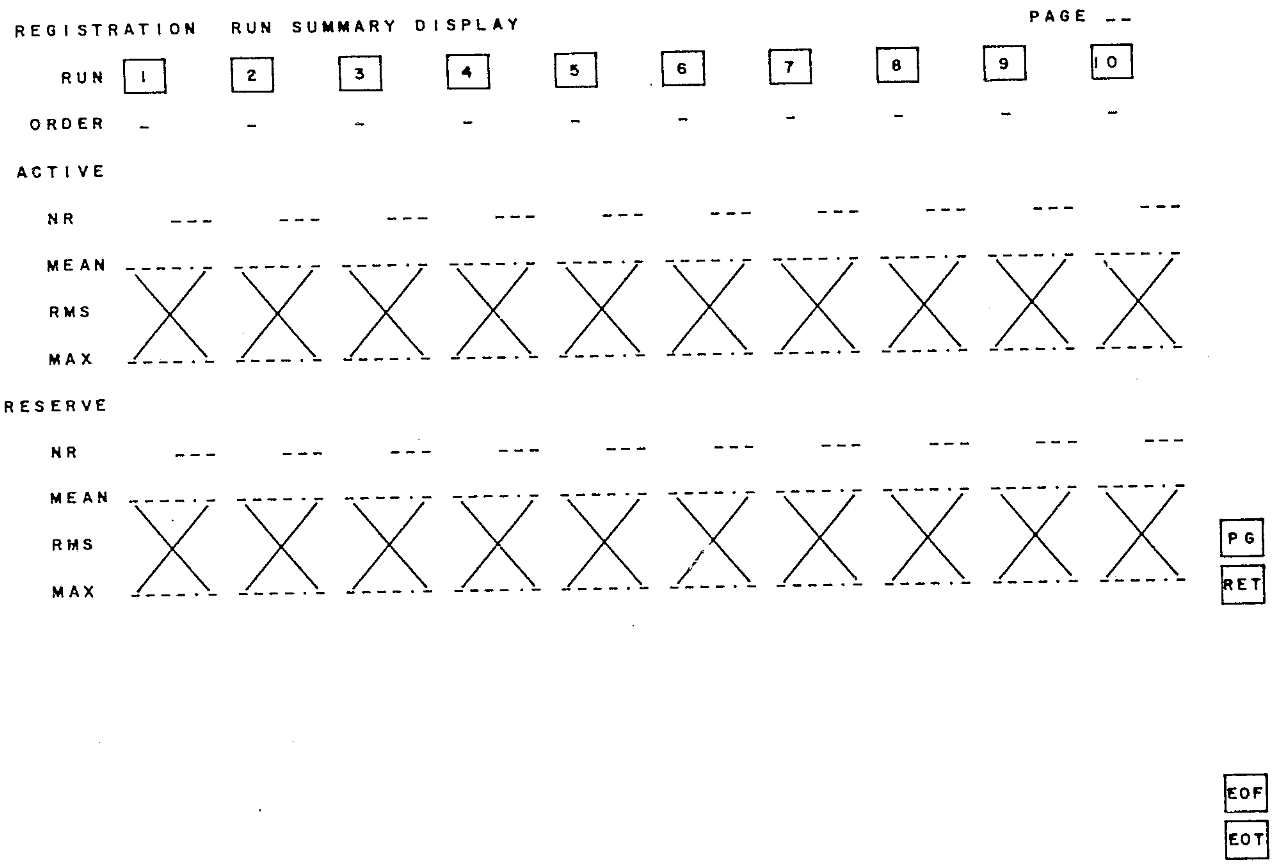

Figure 7.4.4-3 Run Summary Display

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SECTION 8

PATTERN RECOGNITION REQUIREMENTS

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SECTION 8

PATTERN RECOGNITION REQUIREMENTS

8.1 INTRODUCTION

8.1.1 General

With the advent of the Earth Resources Technology Satellite (ERTS), the Earth Resources Aircraft Program (ERAP), the Earth Resources Experiments Program (EREP), and the Large Area Crop Inventory Experiment (LACIE), NASA/JSC needs an operational man-computer interactive system to analyyze remotely sensed earth resources data in accordance with current image processing techniques. To accomplish this task, an adaption of the current Purdue University Aircraft Data Display and Data Analysis Program (LARSYS) techniques will be implemented into the Real-Time Computer Complex (RTCC). The LARSYS program was chosen because it is a man-machine interactive program for analyzing aircraft multispectral scanner data and has been operating successfully in performing crop classification for some time.

Since Purdue University is primarily a research institute, the LARSYS program changes as new ideas are tried and implemented. The JSC pattern recognition program will be an operational program under change control with the initial base program being the Purdue LARSYS program dated June 10,1971. As new ideas become proven and operational, they may be added to the pattern recognition program.

The pattern recognition program will be implemented using the LARSYS (PURDUE) math techniques. Major changes will be made in the man-machine interface, due to hardware differences between Purdue and JSC and due to desired interactive system improvements.

Several pattern recognition applications require repetitive computations to examine individual multispectral data elements. On a large image, this process has proved to be excessively time consuming using a serial processing device. The SPP, used as an array processor, performs the calculations in a parallel mode, therefore the SPP effectively increases the throughput of the LACIE/ERIPS system. The specific algorithms/calculations to be subject to SPP processing have been selected on the basis of anticipated performance gains over the 360/75. The general requirement on the 360/75 LACIE/ERIPS pattern recognition program is that the SPP availability dictates the processing required. In the event the SPP is online, the pattern recognition applications will transfer control parameters and imagery data in conjunction with the Supervisor Program to the SPP as defined in the SSP ICD. In the event the SPP is not online, pattern recognition shall be processed by the 360/75. Control parameters for the SPP and 360/75 are identical.

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8.1.2 Program Description

The pattern recognition program will process standard formatted image data. Any user-desired image correction will have been previously accomplished.

The purpose of the pattern recognition program is to allow the user to classify each picture element (pixel) or group of picture elements (field) of an image into one of up to 60 user-defined subclasses. This task is accomplished in five steps; displaying individual channels of an image (actually accomplished in IMD of Section 6), computing statistics for the image, selecting the best set of channels to separate the desired subclasses of data, classifying each pixel or field, and displaying the final classification results. The user will have the capability to recycle to any previous step, provided he has not overlaid the desired step input data with computation related to another image, set of subclasses, etc. Output data from the latest computations in each step will be recallable.

The initial step, displaying individual channels of the image (again from IMD), provides the user with an overall view of the image from which he can determine the training fields (ground truth) he wants used in "training" the classifier. A field will be any N-sided polygon area where N is not to exceed 10. A designated channel of the image can be displayed in three different ways; on a CRT with up to 16 levels of intensity (gray levels), or on a color CRT with up to 64 different colors. Each gray level or color level will be representative of a relative radiance in the channel being displayed. The user defines his training fields either with the pointer or by menu (if he has a previous knowledge of his training fields) and designates which subclass he wants each field assigned to. When operating in the batch environment (normal LACIE operation) field definitions will be retrieved from the fields data base.

In the second step, the user will generate a set of statistics for each desired subclass. These statistics are used by the separability step for choosing the best set of channels for separating particular types of subclasses. For each subclass, the processor will generate a mean and a standard deviation for each channel. The processor will also compute a covariance and a correlation matrix between all channels for each subclass. The user will have the capability to compute and display desired histograms for each subclass or field. The histograms provide the users with a plot of the number of data points per relative radiance in a desired channel for a desired subclass or field. The histograms are used to verify that the data in each subclass follows a Gaussian (normal) distribution (the separability and classification steps assume a normal distribution).

Statistics for the LACIE data may be computed in one of three user specified manners, selectable by subclass. The first option is to compute field and subclass statistics from the user-identified training fields (this option also must be performed before exercising either of the following options). The second option is to cluster the fields (by subclass) using the results of the subclass statistics from the first option as starting vectors. The third option is to use the results of the field statistics computation and chain the training fields into subclasses using the Bhattacharyya distance in the chaining decision algorithm.

After the statistics computations, the user may elect to manipulate the statistics to correct for sun angle differences, perform a mean level adjustment or simply modify an ill-conditioned covariance matrix that cannot be inverted.

The user will then have the option to choose the best set of N channels via one of several feature selection processors in order to ensure the most accurate classification of each data point of the image into the subclasses chosen, minimizing the probability of misclassification.

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After the best channels have been chosen, the user has the option of classifying each image pixel into one of the training subclasses. Pixel-by-pixel classifications are done by performing pattern recognition with any user-designated set of training subclasses (final assignment made by maximizing the probability that the particular pixel belongs to a particular subclass.)

The final step in the classification process is to display the results. The user can display the whole image (as in step one) with certain gray levels, color levels, or characters assigned to each subclass. The user can also request that the performance results of the classification be printed or displayed.

At the conclusion, the user may decide to make adjustments to his subclass definitions, channel selection, etc., in order to improve his classification results. He will have the capability to return to any step without losing any of the results of previous steps. Only the latest computations for each step will be saved. The user does have the capability to record the statistics data on tape and later to read the statistics back in, thus saving recomputing the desired statistics.

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8.2 USER INTERFACE REQUIREMENTS

The ERIPS user will have the capability to select the pattern recognition application from the application selection menu after signing onto the system and loading the data necessary for the pattern recognition processing. The user may select this application with either an image loaded or a checkpoint/restart tape loaded.

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8.2.1 General Capabilities

All menus presented to the user in the pattern recognition application will include capabilities; to scroll the image(s), to select the image manipulation and display application, and via error recovery logic to allow unloading and scratching from disk, all without actually exiting the pattern recognition application. Also, the capability will exist to indicate the EOF (End-of-Field) and EOT (End-of-Transmission) on all menus without use of the keyboard. The user may return to the previous menu by indicating a return on any of the menus in this application.

All displayed images in this application will include a position indicator (line and column) on the overlay of the upper right hand corner and the lower left hand corner. The corner positions will be updated as the image(s) scroll is halted.

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8.2.2 Processor Selection

8.2.2.1 Image Specification Menu

Upon entrance to the pattern recognition application the user will be presented with a menu which will request specification of the image name of the image to be processed. (See Figure 8.2.2.1-1) If the user wishes to use subclass statistics from an image to process a second image he may select the box to save current subclass statistics. Fields may then be defined to update the subclass statistics. Of course, both images must have been loaded into the ERIPS and their bandlists must be identical. The user may access Image Merge via the "IM" box on this menu.

8.2.2.2 Processor Selection Menu

After image name specification the user will be requested to select the processor or report he wishes to be executed. These processors and reports will consist of the following:

- Field Selection
- Statistics
- Bhattacharyya Chaining
- Clustering
- Feature Select
- Classification
- Goodness of Fit
- Signature Extension
- Fields Report
- Mean/Standard Deviation Report
- Histogram Report
- Feature Select Report
- Classification Summary Report
- Classification Map
- Chaining Report

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This menu is illustrated in Figure 8.2.2.2-1. Error detection logic will prevent the user from selecting a processor without having computed or loaded the data necessary for the execution of that processor. The user will then have available to him various processor options as described in following paragraphs of this section.

The user will have the capability on this menu to store the statistics that have been computed and manipulated up to that point by cursoring the SST box. To retrieve stored statistics at a later time, the user will corsor the SRT box.

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PATTERN RECOGNITION

IMD
SCR

PLEASE ENTER IMAGE NAME ____________

IM

☐ CHECK THIS BOX IF THE CURRENT SUBCLASS STATISTICS ARE TO BE KEPT

NOTE: IF THE BOX IS SELECTED THEN THE BANDLIST OF THE OLD IMAGE MUST BE IDENTICAL TO THE BANDLIST OF THE IMAGE ENTERED ABOVE

RET

EOF
EOT

Figure 8.2.2.1-1 Image Specification Menu

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PATTERN RECOGNITION

PROCESSOR	REPORT
☐ FIELD DEFINITION	☐ FIELD REPORT
☐ STATISTICS	☐ MEAN/STD DEVIATION REPORT
☐ BHATTACHARYYA CHAINING	☐ HISTOGRAM REPORT
☐ CLUSTERING	☐ FEATURE SELECT
☐ FEATURE SELECTION	☐ CLASSIFICATION SUMMARY REPORT
☐ CLASSIFICATION	☐ CLASSIFICATION MAP
☐ GOODNESS OF FIT	☐ CHAINING REPORT
☐ SIGNATURE EXTENSION	☐
☐	☐
☐	☐

IMD
SCR
FLO
TAP

RET

EOF
EOT

Figure 8.2.2.2-1 Processor Selection Menu

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PATTERN RECOGNITION

PROCESSOR	REPORT	
FIELD DEFINITION	FIELD REPORT	IMD
STATISTICS	MEAN/STD DEVIATION REPORT	SCR
BHATTACHARYYA CHAINING	HISTOGRAM REPORT	FLO
CLUSTERING	DIVERGENCE REPORT	TAP
STATISTICS MANIPULATION	B-DISTANCE SEPARABILITY REPORT	
FEATURE SELECTION	B-MATRIX SUMMARY REPORT	
CLASSIFICATION	CLASSIFICATION SUMMARY REPORT	
GOODNESS OF FIT	CLASSIFICATION MAP	
SIGNATURE EXTENSION		
		RET
		EOF
		EOT

Figure 8.2.2.2-1 Processor Selection Menu

8.2.3 Field Selection Processor

8.2.3.1 Field Selection Menu

The field selection processor will present a menu to the user requesting selection of test, training, miscellaneous, mean level adjustment, designated other or designated unidentifiable fields via the pointer or menu. The user will specify the type of field, the field name to be used (required for all types), and a subclass name (required for training and test fields). The user will then define the field by marking vertices via the pointer or entering each vertex via the keyboard. A representation of this menu is shown in Figure 8.2.3.1-1.

8.2.3.2 Field/Subclass Definition

A field will be defined as any user-designated N-sided polygon area, (two vertex fields will be treated as a special case) where N is not to exceed 10 and will be designated by card input to the fields data base or by interactive terminal input. As each vertex is designated, that vertex and the previous vertex will form a side of the polygon area; i.e., vertices may be defined in a clockwise or counter-clockwise order, but must be consecutively ordered in the direction chosen. Each type of field below will have a subclass name and a subclass symbol associated with it.

- TRAINING FIELDS. Used for computing subclass statistics
- TEST FIELDS. Used to evaluate classification performance. Also, each segment to be classified will be designated as a test field.
- MLA, DESIGNATED FIELDS. Mean level adjustment and designated fields will have specific uses and will be described later. A field name is required but no subclass name is necessary. Designated other and designated unidentifiable default subclass names will be *b̸b̸b̸b̸b̸ and &b̸b̸b̸b̸b̸, respectively.

8.2.3.3 Category/Class/Subclass Logic

The category/class/subclass identification criterion is described in Paragraph 4.8.2.1. Each of the classification and mensuration subsystem processors must address these specified names to extract information required to perform its processes. The manner in which each processor addresses the identifier is as follows:

- STATISTICS. The statistics processor will compute statistics for each category/class/subclass individually; i.e., this processor will consider the lowest subdivision (subclass) as a unique entity. Further processing such as the Bhattacharyya distance field chaining may combine the individual statistics. Identifiers will be updated accordingly.

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- CLUSTERING. This processor may address the category identifier or continue to a lower subdivision (Class or subclass). Then during the cluster chaining activity, the identifiers will again be updated appropriately.

- FEATURE SELECTION/CLASSIFICATION. These processors will address all six characters of the class/subclass identifier and the information on the input batch cards that specify what categories are to be separated as categories from the classes of interest. For classes of interest separation is performed at the class level; i.e., summed over the subclass. A priori values are assigned equally over a category's class and subclass subdivisions. Therefore, it is necessary to ascertain the number of subclasses and the number of classes within a category. Also, the number of subclasses (in the case of classes of interest) is used as an index for summing the density function.

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FIELD SELECTION

IMD

SCR

PLEASE SELECT FIELD TYPE TEST ☐ TRNG ☐ MLA ☐ DO ☐ DU ☐

FIELD NAME -------

FIELD SUBCLASS-----

TO ENTER FIELD BOUNDARIES:
VIA CURSOR-CURSOR VERTICES,ENTER EOF,ENTER EOT
VIA KEYBOARD-ENTER EOF,TYPE VERTICES IN ORDER,ENTER EOT
NOTE-LAST VERTEX MUST = FIRST VERTEX

VERTEX	LINE	PIXEL	VERTEX	LINE	PIXEL
1	-----	-----	6	-----	-----
2	-----	-----	7	-----	-----
3	-----	-----	8	-----	-----
4	-----	-----	9	-----	-----
5	-----	-----	10	-----	-----
			11	-----	-----

RET

EOF

EOT

Figure 8.2.3.1-1 Field Selection Menu

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8.2.4 Statistics Processor

8.2.4.1 Statistics Options Menu

The Statistics Options Menu is shown in Figure 8.2.4.1-1. The user will cursor one of the available options and will be presented with another input menu in all cases except the COMPUTE STATISTICS FOR ALL TRAINING FIELDS option. In this case the ERIPS will simply execute the command. The following paragraphs will define the other options available to the user from this menu or transmit field data to the SPP, as defined in the ICD, depending on the system mode of operation.

8.2.4.1.1 Change Field Status Menu

If the user cursors the option to delete fields and/or statistics or change type of field, he will be presented the menu represented in Figure 8.2.4.1.1-1. This menu will request the user to type the names of fields that he wants redefined and then a new field status symbol as defined on the menu. Statistics updating will be done as appropriate for each status change either by the 360/75 or by the SPP.

8.2.4.1.2 Redefine Subclass/Define New Subclass Menu

If the user cursors the option to redefine a subclass; i.e., break some training fields from one subclass to another subclass, or define a new subclass, the menu shown in Figure 8.2.4.1.2-1 will be presented. This menu requests specification of a subclass name and symbol, and then specification of the fields to be assigned to that subclass. All statistics updates will be generated.

8.2.4.1.3 Combine Subclasses Menu

Another option on the Statistics Options Menu is a combine subclasses option. If the user selects this option, the result will be the menu shown in Figure 8.2.4.1.3-1. This menu also requests specification of a subclass name and a subclass symbol. The user will then be able to type in the names of the subclasses to be combined. The user may assign a new subclass into the first entry or an existing subclass. If the class exists, the subclass name will also be listed in the subclasses to be combined column. Statistics updates will automatically be computed.

8.2.4.1.4 Delete Subclasses Menu

When the user selects the delete subclasses option, the menu shown in figure 8.2.4.1.4-1 will be displayed. The user will then specify the subclasses to be deleted by cursoring the ALL SUBCLASSES box, ALL SUBCLASSES EXCEPT box with the exceptions, or the individual subclasses.

8.2.4.1.5 Sun Angle Correction Menu

When the user is operating in the LACIE mode; i.e., with a LACIE merged image that has been retrieved from the image data base, cursoring the SUN ANGLE CORRECTION box on the Statistics Option Menu will cause the Sun Angle Correction Menu (figure 8.2.4.1.5-1) to be displayed. The user will then cursor the appropriate sun angle correction boxes and then type the subclasses to be corrected. The correction will be done from the training segment identified to the recognition segment identified. If the user selects the ALL box, all of the subclasses within the specified training segment will be corrected.

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SPECIFY STATISTICS OPTIONS

IMD

SCR

PLEASE SPECIFY STATISTICS OPTION DESIRED:

☐ COMPUTE STATISTICS FOR ALL TRAINING FIELDS

☐ DELETE FIELDS AND/OR STATISTICS OR
CHANGE TYPE OF FIELD

☐ REDEFINE SUBCLASS/DEFINE NEW SUBCLASS

☐ COMBINE SUBCLASSES

☐ DELETE SUBCLASS

☐ SUN ANGLE CORRECTION

☐ MEAN LEVEL ADJUSTMENT

RET

EOF

EOT

Figure 8.2.4.1-1 Statistics Option Menu

CHANGE FIELD STATUS MENU

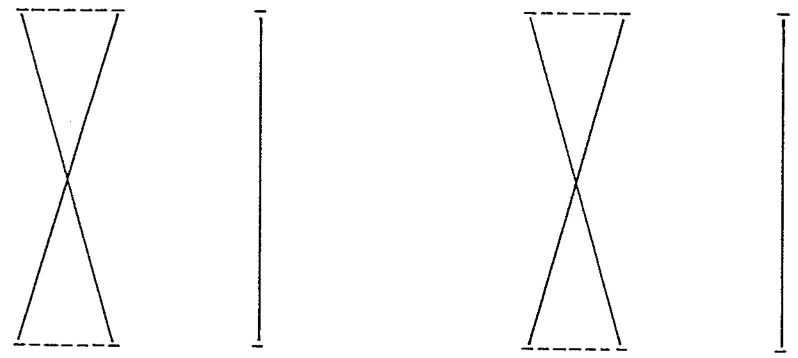
IMD

SCR

PLEASE TYPE FIELD NAME AND NEW STATUS SYMBOL AS FOLLOWS:

T=TRAINING
P=TEST
M=MISCELLANEOUS
D=DELETE

FIELD NAME	NEW STATUS	FIELD NAME	NEW STATUS



RET

EOF

EOT

Figure 8.2.4.1.1-1 Change Field Status Menu

Approved: ________ NASA/DPB ________ PHO

REDEFINE SUBCLASS/DEFINE NEW SUBCLASS MENU

IMD

SCR

PLEASE TYPE NEW SUBCLASS NAME

SUBCLASS NAME ------

AND THEN SPECIFY FIELDS TO BE ASSIGNED TO THAT SUBCLASS

RET

EOF

EOT

Figure 8.2.4.1.2-1 Redefine Subclass/Define New Subclass Menu

Approved: ______ NASA/DPB ______ PHO

COMBINE SUBCLASSES MENU

IMD

SCR

PLEASE TYPE NEW SUBCLASS NAME

SUBCLASS NAME ------

AND THEN SPECIFY SUBCLASSES TO BE COMBINED:

RET

EOF

EOT

Figure 8.2.4.1.3-1 Combine Subclasses Menu

Approved:____NASA/DPB ____PHO

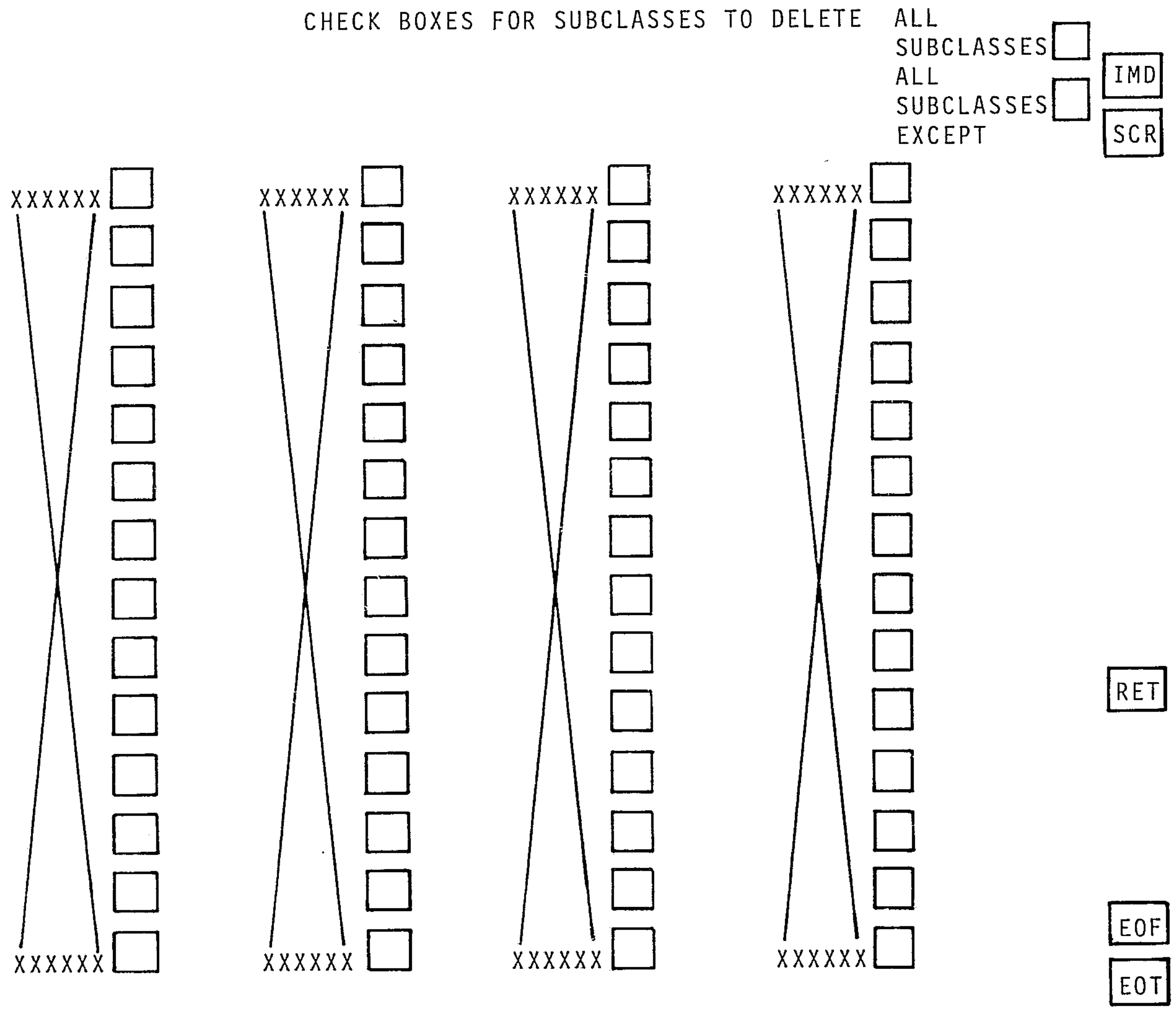


Figure 8.2.4.1.4-1 Delete Subclasses Menu

Approved: ______ NASA/DPB ______ PHO

SUN ANGLE CORRECTION MENU

[IMD]
[SCR]

RECOGNITION SEGMENT [R] [T1] [T2] [T3]

TRAINING SEGMENT [R] [T1] [T2] [T3]

TYPE SUBCLASSES TO BE CORRECTED:

[ ] ALL

[RET]

[EOF]
[EOT]

Figure 8.2.4.1.5-1 Sun Angle Correction Menu

Approved: ____ NASA/DPB ____ PIO

8.2.4.1.6 Mean Level Adjustment Menu

When the user cursors the MEAN LEVEL ADJUSTMENT option (applicable only in the LACIE mode), the menu shown in figure 8.2.4.1.6-1 will be displayed. This menu provides the same functions for mean level adjustment (MLA) as described for sun angle correction, paragraph 8.2.4.1.5. In addition, the MLA menu provides an AVG box. If the user selects the AVG box for the training segment, the average of the MLA fields will be used to compare against the MLA field of the recognition segment to compute the adjustment constant.

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MEAN LEVEL ADJUSTMENT MENU

IMD

RECOGNITION SEGMENT R T1 T2 T3

SCR

TRAINING SEGMENT R T1 T2 T3 AVG

TYPE SUBCLASSES TO BE ADJUSTED:

ALL

RET

EOF

EOT

Figure 8.2.4.1.6-1 Mean Level Adjustment Menu

Approved: NASA/DPB PHO

8.2.5 BHATTACHARYYA Chaining Processor

8.2.5.1 BHATTACHARYYA Subclass Definition Menu

The BHATTACHARYYA Chaining Processor will be selectable from the Pattern Recognition Processor Selection Menu. The user will then be presented with the BHATTACHARYYA Subclass Definition Menu (Figure 8.2.5.1-1) requesting specification of the subclass names that are to be chained and the channels that are to be used in performing the chaining. As with the clustering processor the BHATTACHARYYA chaining processor will allow and recognize category, class or subclass inputs. Also, chaining may be done using a subset of the total number of channels but statistics updates will be performed for all available channels.

8.2.5.2 BHATTACHARYYA Chaining Menu

The next menu to be presented to the user is the BHATTACHARYYA Chaining Menu (Figure 8.2.5.2-1). The user will type in a threshold value and hit the EOT key. The chaining process will begin and when complete the subclasses that were assigned to the chains will be displayed to the user. The user will then type in chain names and hit EOT to have the statistics stored or simply return to cancel storage.

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JSC-10152
(SISO-TR514)

BHATTACHARYYA CLASS DEFINITION MENU

[IMD]

[SCR]

ENTER SUBCLASS NAMES TO BE CHAINED:

------ ------ ------ ------
------ ------ ------ ------
------ ------ ------ ------
------ ------ ------ ------
------ ------ ------ ------

AND SELECT CHANNELS TO BE USED

[ALL]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]

[RET]

[EOF]

[EOT]

Figure 8.2.5.1-1 BHATTACHARYYA Subclass Definition Menu

Approved: ______ NASA/DPB ______ PHO

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

BHATTACHARYYA CHAINING MENU

IMD

CHAINING THRESHOLD, TYPE IN, HIT EOT ___

TYPE CHAIN NAME

SCR

1. XXXXXX,XXXXXX,XXXXXX,XXXXXX,XXXXXX,XXXXXX,XXXXXX
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15. XXXXXX,XXXXXX,XXXXXX,XXXXXX,XXXXXX,XXXXXX,XXXXXX

RET

EOF

EOT

Figure 8.2.5.2-1 BHATTACHARYYA Chaining Menu

Approved: ______ NASA/DPB ______ PHIO

8.2.6 Statistics Manipulation Options

8.2.6.1 Statistics Manipulation Menu

After selection of the statistics manipulation option on the processor selection menu the user will have displayed to him the Statistics Manipulation Menu shown in Figure 8.2.6.1-1. The menu will request that he specify either Sun Angle Correction or Mean Level Adjustment Options. If sun angle correction is specified, the user will also type in a reference sun angle (corresponding to the sun angle of the image to be processed) and an object sun angle (corresponding to the sun angle of the image that was used for statistics generation).

8.2.6.2 Statistics Manipulation Class Specification Menu

Specification of a statistics manipulation option and striking of the EOT key will result in a display of the menu shown in Figure 8.2.6.2-1. The user will respond to this menu by typing in the class names whose statistics he wishes to have manipulated in the specified manner.

Approved: TEP ______ NASA/DPB ______ R.M.L. ______ PHO

STATISTICS MANIPULATION MENU

[IMD]

[SCR]

SELECT MANIPULATION OPTION:

[ ] SUN ANGLE CORRECTION

AND TYPE IN:
REFERENCE SUN ANGLE __

OBJECT SUN ANGLE __

[ ] MEAN LEVEL ADJUSTMENT

[RET]

[EOT]

[EOT]

Figure 8.2.6.1-1 Statistics Manipulation Menu

Approved: ________ NASA/DPB ________ PIIO

STATISTICS MANIPULATION CLASS SPECIFICATION MENU

PLEASE TYPE NAMES OF CLASSES TO BE PROCESSED

IMD

SCR

RET

EOF

EOT

Figure 8.2.6.2-1 Statistics Manipulation Class Specification Menu

Approved: ______ NASA/DPB ______ PHO

8.2.7 Feature Selection

8.2.7.1 Feature Selection Processor Selection Menu

The menu shown in Figure 8.2.7-1 will be presented to the user when the Feature Selection option on the Pattern Recognition Application Selection Menu is chosen. The user may then select one of four principal options for further processing to determine the optimal channel subset (or linear combinations) on which to perform classification or to create an enhanced output image of maximum contrast. One of the four options, the calculation of only the B-distance separability, provides only a report of the separability computations as described in Paragraph 8.3.2.2, and no reduction in the channel set. On this menu the user is also requested to specify channels to be eliminated from consideration prior to any feature selection processing. The maximum channel set size permissible for the divergence option is 30; all other calculations require a consideration of at most 16 channels. An error message will be generated on user failure to eliminate sufficient channels for these options.

8.2.7.2 Feature Selection Subclass Input Menu

The next menu to be presented (figure 8.2.7-2) to the user will request that he specify, by cursoring the appropriate boxes, what subclasses he wishes to separate. The user may cursor ALL SUBCLASSES, ALL SUBCLASSES EXCEPT, or individual subclasses. The ALL SUBCLASSES selection will cause the chosen feature selection processor to compute the separations for all subclasses that have had statistics computed. The ALL SUBCLASSES EXCEPT selection will allow the user to eliminate a small number of subclasses with minimum input activity. For the individual subclass selection the menu will list subclass names and the user will simply cursor the box alongside the appropriate subclass name.

8.2.7.3 Exhaustive Search Divergence Processor

8.2.7.3.1 Divergence Checklist Menu

The divergence or channel selection processor will present a menu (Figure 8.2.7-3) to the user. The user will then specify the channel set size (default is four), the DIJMAX to use (default is 999, refer to Paragraph 8.3.2.1). The user may then specify a channel set, weight the intersubclass divergences, specify a DIJMIN for any of the subclass pairs (refer to Paragraph 8.3.2.1), or use the fixed subclass pair channel set ordering. Many of the options mentioned result in a separate menu being displayed.

8.2.7.3.2 Channel Specification Option

In order to specify channel sets the user will respond to the menu (Figure 8.2.7-4) by cursoring the channel sets that he wishes to specify. The user may specify up to 10 channel sets by cursoring the next desired channel set before cursoring the CONTINUE box. After all sets have been specified, the user should cursor the CONTINUE box and the ERIPS will proceed to the next menu.

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FEATURE SELECTION

IMD
SCR

PLEASE CURSOR THE APPROPRIATE FEATURE SELECTION ACTIVITY :

☐ EXHAUSTIVE SEARCH/DIVERGENCE

☐ BHATTACHARYYA DISTANCE SEPARABILITY ONLY

☐ WITHOUT REPLACEMENT SEARCH/B-DISTANCE SEPARABILITY

☐ FDP ITERATOR/B-DISTANCE SEPARABILITY

EXCLUDE CHANNELS FROM CONSIDERATION BY CURSORING BOXES BELOW :
(NOTE: MAXIMUM NUMBER OF CHANNELS FOR DIVERGENCE IS 30; ALL
OTHER OPTIONS ARE RESTRICTED TO 16 CHANNELS).

RET

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

EOF
EOT

Figure 8.2.7-1 Feature Selection Processor Selection Menu

Approved: ____________ NASA/DPB ____________ PHO

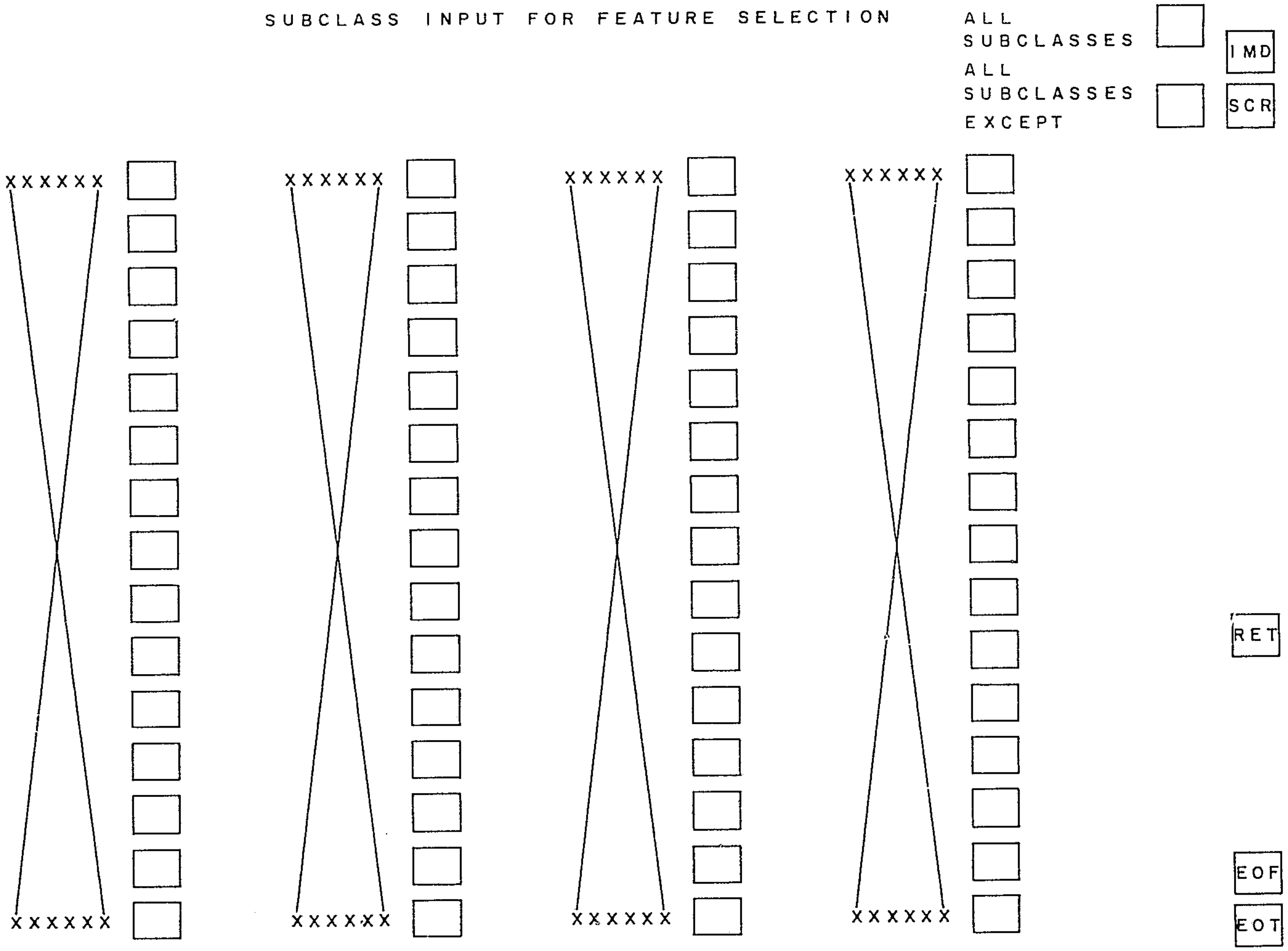

Figure 8.2.7-2 Feature Selection Subclass Input Menu

Approved: ______ NASA/DPB ______ PHO

DIVERGENCE CHECKLIST

IMD

SCR

CHANNEL SET SIZE -- DEFAULT IS 4

DIVERGENCE MAXIMUM --- DEFAULT IS 999

DO YOU DESIRE TO SPECIFY A CHANNEL SET

DO YOU DESIRE TO ASSIGN WEIGHTING FACTORS

DO YOU DESIRE TO SET MINIMUM DIVERGENCE CRITERION

DO YOU DESIRE FIXED SUBCLASS PAIR CHANNEL SET ORDERING

RET

EOF

EOT

Figure 8.2.7-3 Divergence Checklist Menu

Approved: ______ NASA/DPB ______ PHO

IMD

SCR

PLEASE CHECK THE CHANNELS
FOR SPECIAL CHANNEL SET

1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
11 ☐	12 ☐	13 ☐	14 ☐	15 ☐
16 ☐	17 ☐	18 ☐	19 ☐	20 ☐
21 ☐	22 ☐	23 ☐	24 ☐	25 ☐
26 ☐	27 ☐	28 ☐	29 ☐	30 ☐

☐ CONTINUE

RET

EOF

EOT

Figure 8.2.7-4 Channel Specification Option

Approved: ________ NASA/DPB ________ PHO

8.2.7.3.3 Weighting Factors Option

The menu to input the weighting factors for the intersubclass divergences is illustrated in Figure 8.2.7-5. The user may specify a subclass pair and a weighting factor, a single subclass and a weighting factor, or no subclasses and a weighting factor. If two subclasses are entered, the weighting factor will apply only to that subclass pair. If a single subclass is entered, the weighting factor will apply to all subclass pairs. The user then may enter no subclasses; i.e., blanks, on the first line and then override that weighting factor for single subclasses or subclass pairs in following entries.

8.2.7.3.4 Minimum Divergence Option

The user may specify minimum divergence values for subclass pairs by responding to the menu shown in Figure 8.2.7-6. He will enter a minimum divergence value and all the subclass pairs that will be affected or he may cursor ALL and that value will be applied to all subclass pairs. As in the previous menu if the user specifies a single subclass the minimum divergence value will apply to all subclass pairs containing the specified subclass.

8.2.7.3.5 Subclass Pair Ordering Option

8.2.7.4 B-distance Separability Functions

When a user specifies the subclass pair ordering option, he will be presented with the menu shown in Figure 8.2.7-7 and be requested to specify the subclass pair to be used for the divergence processor ordering.

8.2.7.4.1 Separability Definition Menu

The menu shown in Figure 8.2.7-8 will be displayed on selection of any of the B-distance options on The Feature Selection Processor Selection Menu (Figure 8.2.7-1). The user is able on this menu to specify those subclasses which are to be treated as subclasses of non-interest for calculation of total separability, as described in Paragraph 8.3.2.2.1. Up to 20 subclasses may be defined on this menu.

8.2.7.4.2 A PRIORI Value Definition Menu

The menu shown in Figure 8.2.7-9 will be displayed on EOT from the Separability Definition Menu. All categories of the classes and subclasses defined via the Feature Selection Subclass Input Menu (Figure 8.2.7-2) will be indicated on the menu; the user will be able to select A PRIORI values in the same manner and under the same constraints specified for the Classification A PRIORI values (q.v. Paragraphs 8.2.8.4 and 8.3.3.1). On the EOT from this menu, the B-distance separability option will be executed on all channels not specifically excluded on the Feature Selection Processor Selection Menu.

8.2.7.4.3 Output Channel Subset Definition Menu

The menu shown in Figure 8.2.7-10 will be displayed on EOT from the previous menu if either the WITHOUT REPLACEMENT or FDP ITERATOR option was selected on the Feature Selection Processor Selection menu (Figure 8.2.7-1). The controls available to the user are (1) a ratio between total channel set separability and determined subset separability, defaulted to 0.900, and (2) the number of channels to be output by the FDP iterator. The options are defined on the menu and in Paragraph 8.3.2.2. On EOT from this menu the specified activity will be performed; on completion, the Pattern Recognition Application Selection Menu will be displayed.

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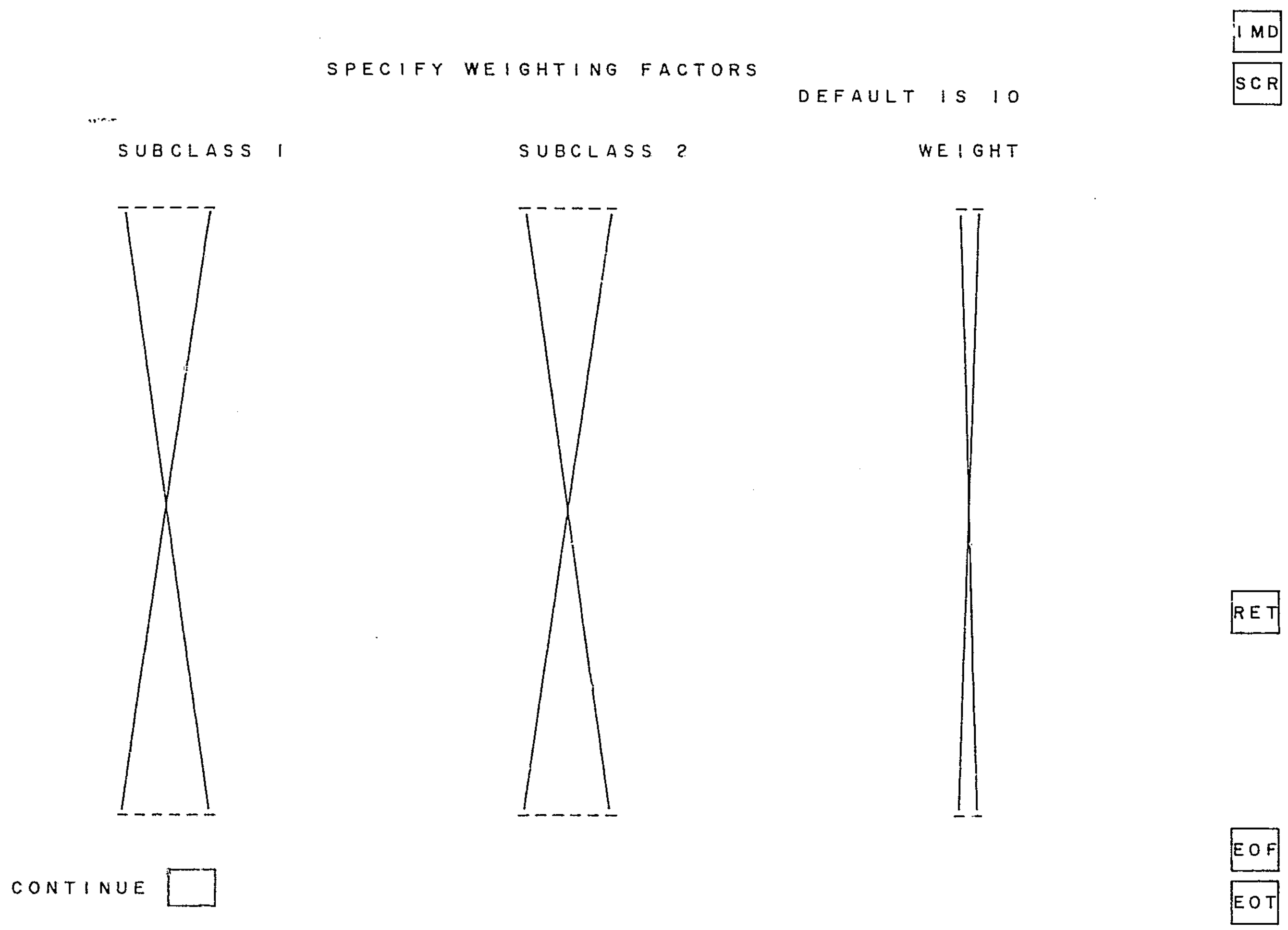


Figure 8.2.7-5 Weighting Factors Option

Approved: ____________ NASA/DPB ____________ PHO

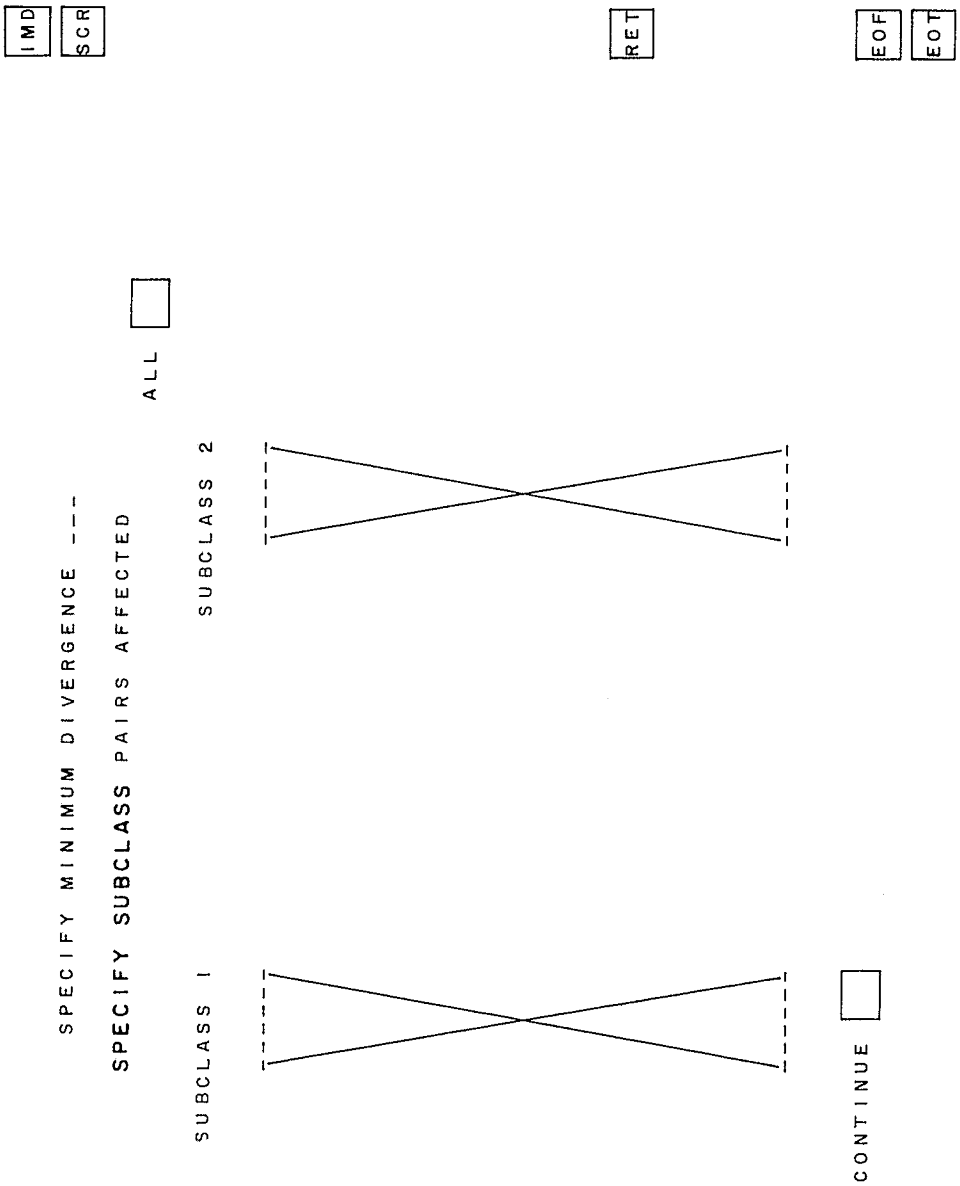


Figure 8.2.7-6 Minimum Divergence Options

Approved: ______ NASA/DPB ______ PHO

PLEASE SPECIFY SUBCLASS PAIR FOR CHANNEL SET ORDERING

SUBCLASS 1 ------

SUBCLASS 2 ------

IMD SCR RET EOF EOT

Figure 8.2.7-7 Subclass Pair Ordering Option

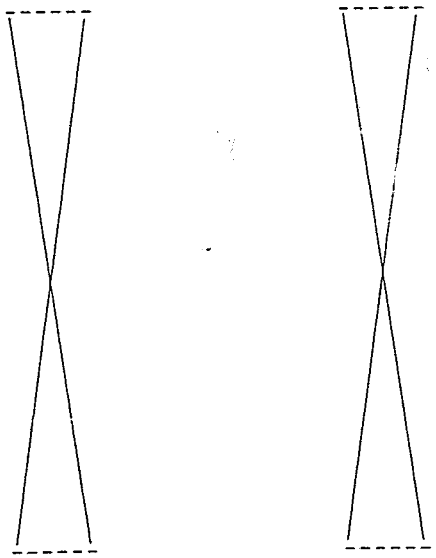
Approved: ______ NASA/DPB ______ PHO

SEPARABILITY DEFINITION

IMD

SCR

THE FOLLOWING CLASSES (AND ASSOCIATED SUBCLASSES) ARE TO BE TREATED AS A SINGLE CATEGORY DISTINCT FROM ALL OTHER CLASSES FOR CALCULATION OF THE TOTAL SEPARABILITY MEASURE :



RET

EOF

EOT

Figure 8.2.7-8 Class Separability Definition Menu

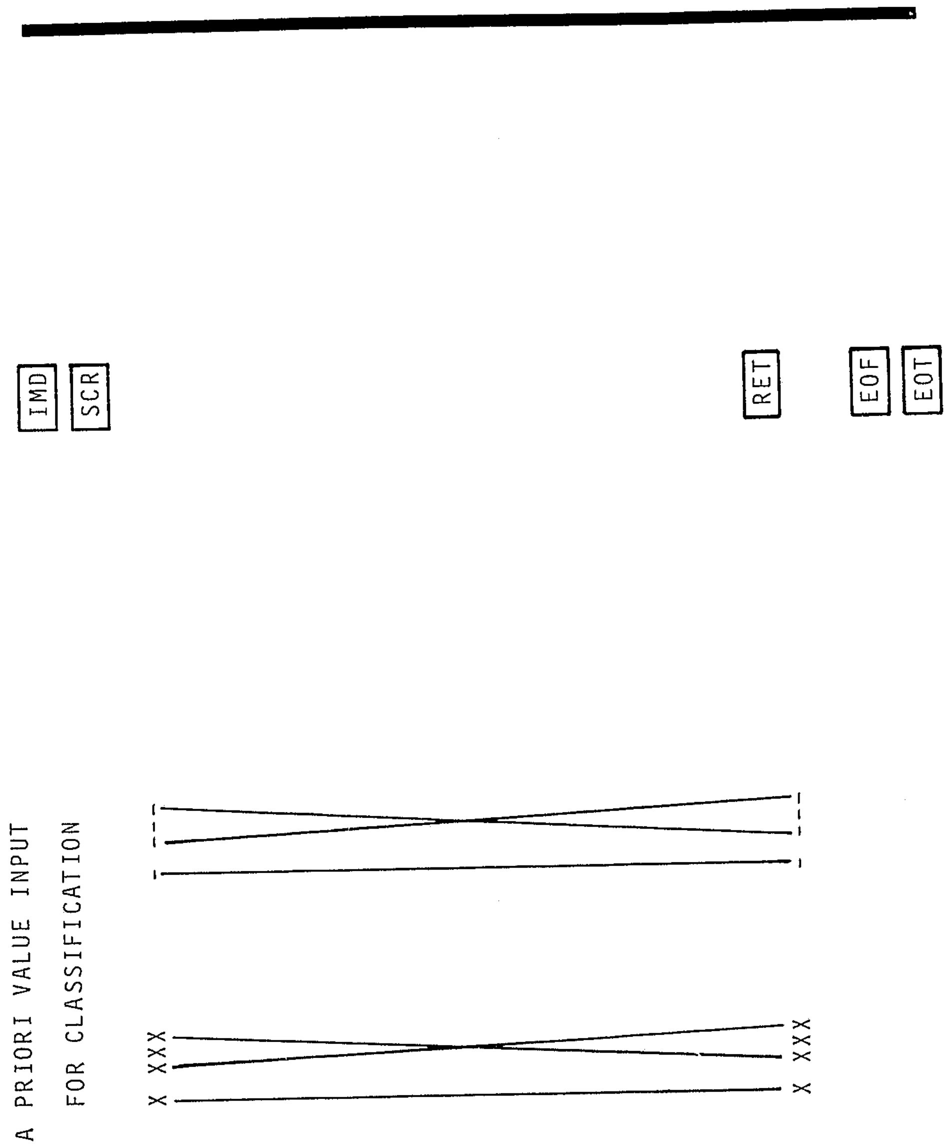


Figure 8.2.7-9 A Priori Input Menu

Approved: NASA/DPB PHO

OUTPUT CHANNEL SET DEFINITION MENU

IMD

SCR

```
PLEASE SPECIFY SEPARABILITY RATIO CRITERION FOR
CHANNEL SUBSET (DEFAULT IS 0.900) :  ._____

IF FDP ITERATOR SELECTED AND YOU WISH TO SELECT
A NUMBER OF OUTPUT CHANNELS, PLEASE SPECIFY : __
(DEFAULT IS TO PERFORM WITHOUT REPLACEMENT
UNTIL THE SEPARABILITY RATIO EXCEEDS THE LEVEL
SPECIFIED ABOVE AND THE NUMBER OF CHANNELS
EXCEEDS THREE.  THE CHANNEL SET THUS DETERMINED
IS THE STARTING MATRIX FOR THE ITERATOR).
```

RET

EOF

EOT

Figure 8.2.7-10 Output Channel Subset Definition Menu

Approved: ______ NASA/DPB ______ PHO

8.2.8 Classification Processor

8.2.8.1 Classification Menu

The Classification Processor will initially display the Classification Menu (Figure 8.2.8.1-1). The user will be requested to specify the channels to be used for the classification process and select the type classification to be used. The user will have the following channel select options to be performed either by the SPP or the 360/75 as a function of the system configuration.

- Divergence best sets, D (AVE), D (MIN), of D (I, J)
- Linear Combination of Channels best set
- Without Replacement Option best set
- Use all channels
- Specify a subset of channels.

The type of classification will be the maximum likelihood classifier and the mixture density function classifier.

8.2.8.2 Subclass Selection Menu

The next menu (Figure 8.2.8.2-1) to be presented to the user by the Classification Processor will request that he identify the classes into which the data is to be classified by cursoring the appropriate boxes. The user may cursor ALL SUBCLASSES, ALL SUBCLASSES EXCEPT, or individual subclasses. The ALL SUBCLASSES selection will cause the Classification Processor to consider all subclasses that have had statistics computed. The ALL SUBCLASSES EXCEPT selection will allow the user to eliminate a few subclasses with minimum input activity. For the individual subclass selection, the menu will list subclass names and the user will cursor the box alongside the appropriate subclass name.

8.2.8.3 Class/Category Specification Menu

The Class/Category Specification Menu (Figure 8.2.8.3-1) will allow the user to specify what categories will be classified only to the class level. The user will specify this by checking the ALL box or by typing in the desired categories one-character name. Default on this menu will be to classify all categories to the category level. Inputs on this menu will be ignored if maximum likelihood was selected on the Classification Menu (Refer to Paragraph 8.2.8.1).

8.2.8.4 A Priori Constant Input Menu

The A Priori Constant Input Menu (Figure 8.2.8.4-1) will be displayed to allow the user to type in category names and specify corresponding a priori classification values. The two left columns will display the category symbol and associated a priori values that have been retrieved from the fields data base. The user may then override all or some of these values by typing the category symbol and a new priori value in the two right hand columns. (Refer to paragraph 8.3.3.1.)

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8.2.8.5 Fields To Be Classified Menu

The user will next be requested to identify by field name the fields to be classified. (See figure 8.2.8.5-1). The user may elect to classify all training fields, all test fields or both. The user may, instead of cursoring the ALL OF THE TRAINING FIELDS box or ALL OF THE TEST FIELDS box, cursor the respective EXCEPT box and then type in the desired exceptions. The user may elect to classify fields of the recognition segment (this option includes classification of the total segment), or the fields of up to three merged training segments. This will be accomplished by cursoring the desired box; e.g., R, T1, T2, or T3. It should be noted that classification will be done by naming fields to be classified rather than naming images to be classified; i.e., the fields must have been defined in the Field Selection Processor Menu (Figure 8.2.3.1-1).

Approved: ______ NASA/DPB ______ PHO

CLASSIFICATION MENU

INDICATE THE CHANNELS TO BE USED IN CLASSIFYING YOUR DATA BY
ONE OF THE FOLLOWING:

IMD

SCR

DIVERGENCE BEST SET: D(AVE [ ] D(MIN) [ ] D(I,J) [ ]

LINEAR COMBINATION OF CHANNELS BEST SET [ ]

WITHOUT REPLACEMENT OPTION BEST SET [ ]

OR

SELECTING ANY OF THE FOLLOWING CHANNELS

ALL	1	2	3	4	5	6	7	8	9	10
	11	12	13	14	15	16	17	18	19	20
	21	22	23	24	25	26	27	28	29	30

RET

AND SPECIFY TYPE OF CLASSIFICATION:

[ ] MAXIMUM LIKELIHOOD

[ ] MIXTURE DENSITY FUNCTION

EOF

EOT

Figure 8.2.8.1-1 Classification Menu

Approved: ______ NASA/DPB ______ PHO

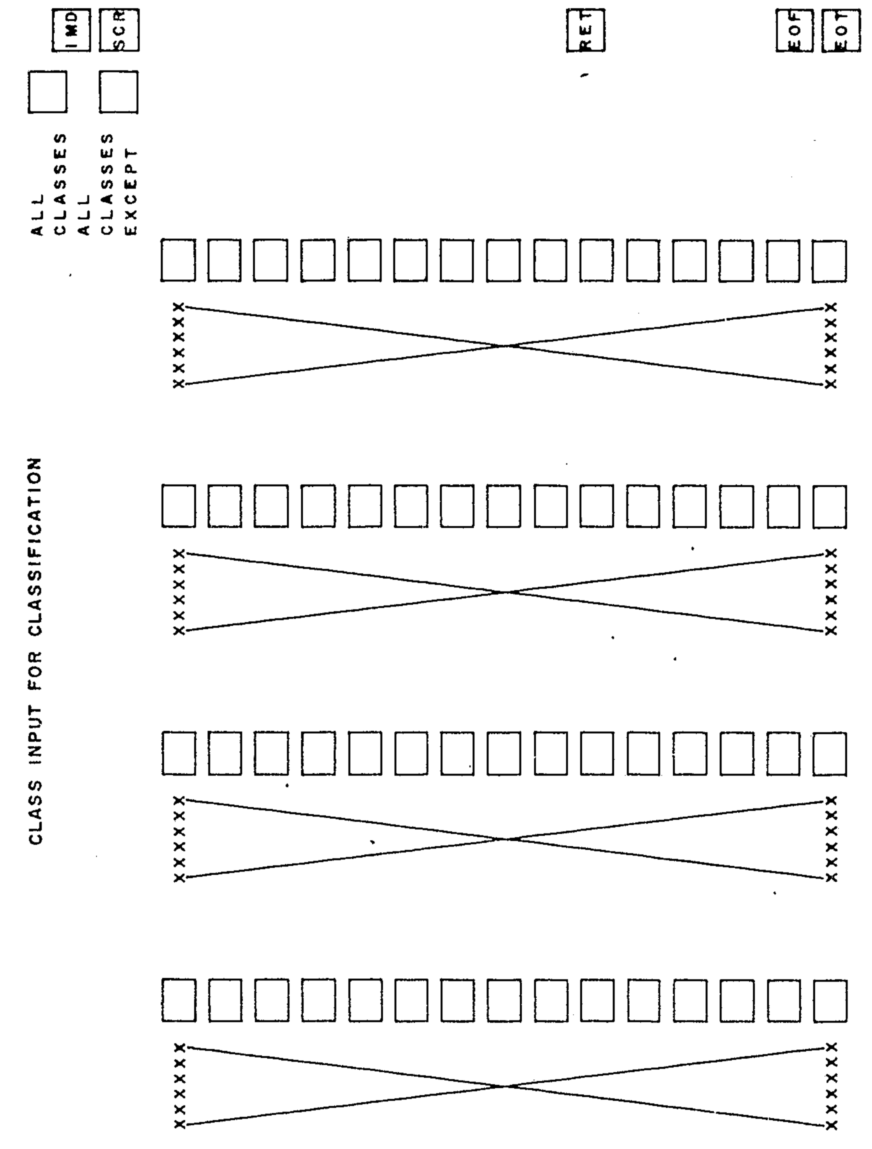

Figure 8.2.8.2-1 Class Selection Menu

Approved: ______________ NASA/DPB ______________ PHO

CLASS/CATEGORY SPECIFICATION MENU

PLEASE CHECK BOX ALL

OR TYPE DESIRED CATEGORIES:

IMD

SCR

RET

EOF

EOT

DEFAULT WILL BE CLASSIFICATION TO CATEGORY LEVEL

NOTE:MAXIMUM LIKELIHOOD DOES NOT UTILIZE SUBDIVISIONS

Figure 8.2.8.3-1 Class/Category Specification Menu

Approved: NASA/DPB PHO

A PRIORI CONSTANT INPUT
FOR CLASSIFICATION

X XXX

X XXX

IMD

SCR

RET

EOF

EOT

Figure 8.2.8.4-1 A Priori Input Menu

Approved: ____________ NASA/DPB ____________ PHO

Approved: _______ NASA/DPB _______ PHO

CLASSIFICATION MENU

PLEASE INDICATE THE FIELDS THAT YOU WANT TO BE CLASSIFIED

ALL OF THE TRAINING FIELDS [ ] EXCEPT [ ]

ALL OF THE TEST FIELDS [ ] EXCEPT [ ]

THE FOLLOWING FIELDS

1 -------	11 -------	21 -------	31 -------	41 -------	51 -------	61 -------
2	12	22	32	42	52	62
3	13	23	33	43	53	63
4	14	24	34	44	54	64
5	15	25	35	45	55	65
6	16	26	36	46	56	66
7	17	27	37	47	57	67
8	18	28	38	48	58	68
9	19	29	39	49	59	69
10 -------	20 -------	30 -------	40 -------	50 -------	60 -------	70 -------

[R] [T1] [T2] [T3]

[IMD] [SCR] [RET] [EOF] [EOT]

Figure 8.2.8.5-1 Fields To Be Classified Menu

JSC-10152
(SISO-TR514)

8.2.9 Classification Map Processor

8.2.9.1 Display Processor

The display processor will compute the classification results to be displayed as a classification map, performance table report, or output in several forms to magnetic tape. The performance table generation is explained in paragraph 8.2.10.6. After responding to the appropriate minus for classification map generation, the user should select the image manipulation and display (IMD) application to display the classification map.

8.2.9.2 Classification Map Menu

The Classification Map Menu (figure 8.2.9.2-1) will be displayed when the user cursors the CLASSIFICATION MAP option on the main Pattern Recognition Menu. The options available on the Classification Map Menu are:

- CHARACTER MAP (FICHE)
- COLOR IMAGE (8)
- COLOR IMAGE (64)
- GRAY LEVEL IMAGE
- IMAGE TAPE
- CHARACTER MAP (PRINT)
- GRAY LEVEL (PRINT)

Each option selected will be cause an appropriate menu to be displayed.

8.2.9.3 Character Map (Fiche) Menu

The Character Map (Fiche) Menu (figure 8.2.9.3-1) allows the user to specify a standard threshold for all subclasses, or a threshold for each individual subclass. The user may also specify a standard threshold for all subclasses and then override that value for a number of subclasses. If the subclass symbols are not defined on this menu, subclass symbols will default to displayed symbols.

8.2.9.4 Color Image Menus

When the user cursors the COLOR IMAGE (8) or COLOR IMAGE (64) box, figures 8.2.9.4-1 or 8.2.9.4-2 are displayed, respectively. The only difference is that the user may specify either 8 or 64 colors.

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CLASSIFICATION MAP MENU

IMD

SCR

INDICATE TYPE OF CLASSIFICATION OUTPUT

1 CHARACTER MAP (FICHE) ☐

2 COLOR IMAGE (8) ☐

3 COLOR IMAGE (64) ☐

4 GRAY LEVEL IMAGE ☐

5 IMAGE TAPE ☐

6 CHARACTER MAP (PRINT) ☐

7 GRAY LEVEL (PRINT) ☐

RET

EOF

EOT

Figure 8.2.9.2-1 Classification Map Output Menu

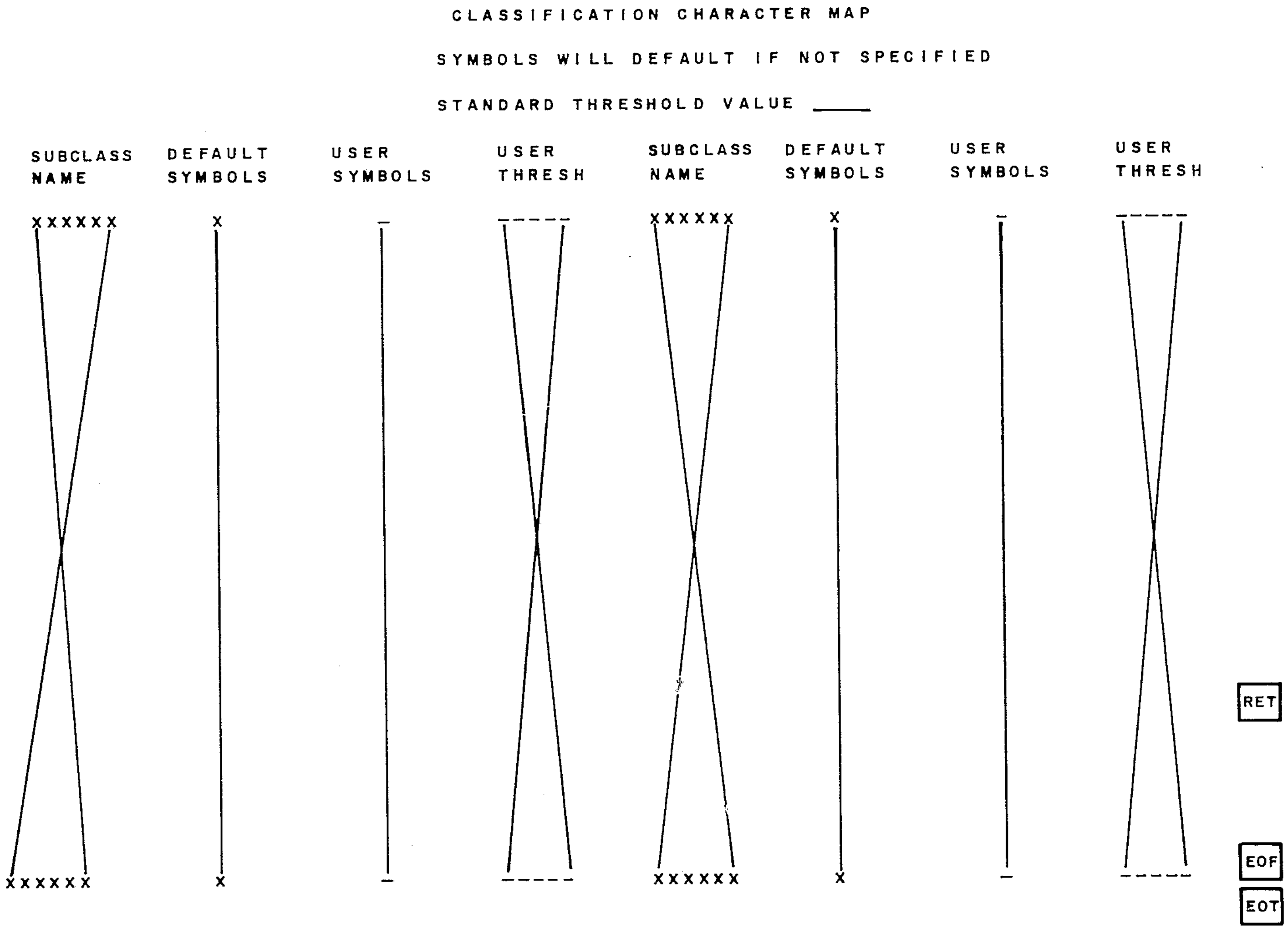

Figure 8.2.9.3-1 Character Map Menu

Approved: ____________ NASA/DPB ____________ PHO

CLASSIFICATION COLOR IMAGE (8)

COLOR	NUMBER	COLOR	NUMBER	COLOR	NUMBER	COLOR	NUMBER
BLACK	0	GREEN	4	RED	8	YELLOW	12
BLUE	2	CYAN	6	MAGENTA	10	WHITE	14

UNCLASSIFIED COLOR NUMBER __

STANDARD THRESHOLD ____

SUBCLASS NAME	DEFAULT COLOR NO	USER COLOR NO	USER THRESH	SUBCLASS NAME	DEFAULT COLOR NO	USER COLOR NO	USER THRESH
XXXXXX	XX	__	_____	XXXXXX	XX	__	_____
XXXXXX	XX	__	_____	XXXXXX	XX	__	_____

RET

EOF

EOT

Figure 8.2.9.4-1 Color Image Menu (8)

Approved: ______ NASA/DPB ______ PHO

```
                         CLASSIFICATION COLOR IMAGE (64)
    COLOR NUMBER    COLOR NUMBER    COLOR NUMBER    COLOR NUMBER    INTENSITY
    BLACK    0      GREEN    4      RED      8      YELLOW   12     ODD NUMBERS 1-15
    BLUE     2      CYAN     6      MAGENTA 10      WHITE    14
    UNCLASSIFIED COLOR NUMBER __
    STANDARD THRESHOLD __
SUBCLASS  DEFAULT      USER       USER    SUBCLASS  DEFAULT      USER       USER
NAME      CLR INTEN    CLR INTEN  THRESH  NAME      CLR INTEN    CLR INTEN  THRESH

XXXXXX    XX  XX       __  __     _____   XXXXXX    XX  XX       __  __     _____

XXXXXX    XX  XX       __  __     _____   XXXXXX    XX  XX       __  __     _____
```

RET

EOF

EOT

Figure 8.2.9.4-2 Color Image Menu (64)

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8.2.9.5 Gray Level Image Menu

The Gray Level Image Menu (figure 8.2.9.5-1) requires the same inputs as the Color Image Menu with the exception that gray levels are specified instead of colors.

8.2.9.6 Image Tape Menu

The Image Tape Menu (figure 8.2.9.6.1) is similar to the 64 Color Image Menu in that the user may specify an intensity level in addition to the color specification. LACIE products generated from this image tape are recorded on both color, and black and white film. Therefore, in order to provide maximum contrast on both types of films, a specific set of default color and intensity levels are used for this menu, refer to table 8.2.9.6-1. The defaults should be selected evenly over the entire list. Black, or color number 1, will always be used for the threshold or null subclass/cluster. If more than 20 subclasses/clusters are present, the defaults will be repeated starting with color number 2. Again color number 1 is to be used for the null subclass/cluster. As an example, with five subclasses/clusters the color number increment would be 4(20/5), the assigned color numbers would be 1 for the null subclass/cluster, and adding the increments 5, 9, 13, 17, and 20 to complete the five colors.

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CLASSIFICATION GRAY IMAGE

UNCLASSIFIED GRAY LEVEL ____

STANDARD THRESHOLD ______

SUBCLASS NAME	DEFAULT GRAY LVL	USER GRAY LVL	USER THRESH	SUBCLASS NAME	DEFAULT GRAY LVL	USER GRAY LVL	USER THRESH
XXXXXX	XX	--	-----	XXXXXX	XX	--	-----
XXXXXX	XX	--	-----	XXXXXX	XX	--	-----

RET

EOF

EOT

Figure 8.2.9.5-1 Gray Image Menu

```
                              CLASSIFICATION IMAGE TAPE
    COLOR NUMBER    COLOR NUMBER    COLOR NUMBER    COLOR NUMBER    INTENSITY
    BLACK      0    GREEN      4    RED        8    YELLOW    12    ODD NUMBERS 1-15
    BLUE       2    CYAN       6    MAGENTA   10    WHITE     14
    UNCLASSIFIED COLOR NUMBER __
    STANDARD THRESHOLD ___
SUBCLASS  DEFAULT      USER       USER     SUBCLASS  DEFAULT      USER       USER
NAME     CLR INTEN   CLR INTEN   THRESH    NAME     CLR INTEN   CLR INTEN   THRESH

XXXXXX    XX   XX    --   --     -----     XXXXXX    XX   XX    --   --     -----

XXXXXX    XX   XX    --   --     -----     XXXXXX    XX   XX    --   --     -----
```

RET

EOF

EOT

Figure 8.2.9.6-1 Image Tape Menu

Approved: ______ NASA/DPB ______ PHO

TABLE 8.2.9.6-1

DEFAULT COLOR AND INTENSITY LEVELS

Color No.	Color	Intensity	Bit Pattern	Color Decimal	Intensity decimal
1	BLACK		00000000	0	0
2	BLUE	DARK	00110001	2	1
3		MEDIUM	00110111	2	7
4		BRIGHT	00111111	2	15
5	GREEN	DARK	01010001	4	1
6		MEDIUM	01010111	4	7
7		BRIGHT	01011111	4	15
8	CYAN	DARK	01110001	6	1
9		MEDIUM	01110111	6	7
10		BRIGHT	01111111	8	1
11	RED	DARK	10010001	8	1
12		MEDIUM	10010111	8	7
13		BRIGHT	10011111	8	15
14	MAGENTA	DARK	10110001	10	1
15		MEDIUM	10110111	10	7
16		BRIGHT	10111111	10	15
17	YELLOW	DARK	11010001	12	1
18		MEDIUM	11010111	12	7
19		BRIGHT	11011111	12	15
20	WHITE		11111111	14	15

8.2.9.7 Character Map (Printer) Option

When the user selects the Character Map (Printer) option the menu shown in figure 8.2.9.3-1 will be displayed. User inputs to the Character Map (Printer) option are the same as for the Character Map (Fiche) Menu.

8.2.9.8 Gray Level (Printer) Option

When the user selects the Gray Level (Printer) option the menu shown in figure 8.2.9.5-1 will be displayed and require the same inputs as described in paragraph 8.2.9.5.

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8.2.10 Report Selection

8.2.10.1 General

The user should be able to select the following reports from the main pattern recognition menu.

- Field Definition Report
- Histogram Report
- Mean-Standard Deviation Report
- Feature Select Report
- Classification Summary Report
- Mensuration Report
- Chaining Report

These reports will be presented on the conversational screen upon request by the user. After the user selects a particular report, he will be presented a menu that will request specification of the data that is to be displayed. A description of the reports and an example of each one are presented in Paragraph 8.4. The menus that allow specification of the data options will be described in the following paragraphs.

8.2.10.2 Field Definition Report Menu

The field definition report menu will allow the user to specify that he wishes to see the definitions of the training fields, the test fields or all fields. This menu is shown in Figure 8.2.10.2-1.

8.2.10.3 Histogram Report Menu

As shown in Figure 8.2.10.3-1 the histogram report menu will request that the user specify, by cursoring the desired boxes, which channel number are to be used for the histograms. The user may elect to specify the horizontal scaling by typing in maximum and minimum radiance levels. The user may then select subclasses and/or fields by typing in individual names. Since this capability could result in 600 figures (200 pages), the ERIPS will limit the number of figures per report to 30 (10 pages). The user will be notified when he has exceeded this limit and asked to decrease his demands.

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FIELD DEFINITION REPORT MENU

PLEASE SELECT THE TYPE OF FIELDS TO BE DEFINED

TRAINING FIELDS ☐

TEST FIELDS ☐

ALL FIELDS ☐

IMD SCR RET EOF EOT

Figure 8.2.10.2-1 Field Definition Report Menu

Approved: TGP NASA/DPB KWS PHO

HISTOGRAM REPORT MENU

IMD
SCR

PLEASE SELECT CHANNELS TO BE HISTOGRAMMED

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30

PLEASE INPUT RADIANCE LIMITS—MAXIMUM --- DEFAULT=255
MINIMUM --- DEFAULT=0

PLEASE ENTER SUBCLASSES OR FIELDS TO BE HISTOGRAMMED

RET

SUBCLASSES	FIELDS
XXXXXX	XXXXXXX
XXXXXX	XXXXXXX

EOF
EOT

Figure 8.2.10.3-1 Histogram Report Menu

Approved: NASA/DPB PHO

8.2.10.4 Mean-Standard Deviation Report Menu

The user will be able to specify on the mean-standard deviation report menu (see Figure 8.2.10.4-1) whether he wishes to see the report for subclasses, for fields or for both.

8.2.10.5 Feature Select Report Option

8.2.10.5.1 Divergence Report Menu

On the divergence report menu the user is asked to please select the ordering option that he wishes to have displayed; D (AVE), DIJMIN or the fixed pair, D (I,J), option. This menu is shown in Figure 8.2.10.5-1. The divergence report will consist of two pages and is described in Section 8.4.

8.2.10.5.2 Feature Select Reports

The feature select report from the without replacement Bhattacharyya computations will be generated automatically when the user selects the feature select option, if the feature selection has been run. No other menu inputs are required for this report.

8.2.10.6 Classification Summary Report Menu

The Classification Summary Report Menu will request the user to input threshold values for each of the categories. The user may specify a threshold value for all categories or a threshold for each of the categories as shown in Figure 8.2.10.6-1. The default threshold for the classification summary report will be 0.0 percent.

The user will also be able to specify mensuration, if desired. This request will invoke the Mensuration Report Menu for specific user inputs.

8.2.10.7 Mensuration Report Menu

The Mensuration Report Menu will request the user to specify the conversion factors to be applied to field and subclass pixel counts for output to the Detailed Classification Summary. The capability to specify units of acres, hectares, or square kilometers will be provided, as well as an area value (in the selected unit per pixel (see Figure 8.2.10.7-1).

8.2.10.8 Chaining Report.

A chaining report shall be generated when the user selects the CHAINING REPORT Box. No other menu inputs are required.

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MEAN AND STANDARD DEVIATION REPORT MENU

PLEASE SELECT THE DESIRED REPORT

SUBCLASS REPORT [ ]

FIELD REPORT [ ]

BOTH REPORTS [ ]

IMD

SCR

RET

EOF

EOT

Figure 8.2.10.4-1 Mean-Standard Deviation Report Menu

DIVERGENCE REPORT MENU

R

PLEASE SELECT ORDERING OPTION

RANKING WITH RESPECT TO D(AVE) ☐

RANKING WITH RESPECT TO D(MIN) ☐

RANKING WITH RESPECT TO USER (I,J,) PAIR ☐

RET

EOF

EOT

Figure 8.2.10.5-1 Divergence Report Menu

Approved: ____________ NASA/DPB ____________ PHO

CLASSIFICATION SUMMARY MENU

IMD

SCR

PLEASE ENTER THRESHOLD VALUES

ALL CATEGORIES --.-%

OR VALUE FOR EACH SUBCLASS

☐ SPECIFY MENSURATION, IF DESIRED

☐ CAS INTERFACE

SUBCLASS	VALUE	SUBCLASS	VALUE	SUBCLASS	VALUE	SUBCLASS	VALUE
XXXXXX	__._%	XXXXXX	__._%	XXXXXX	__._%	XXXXXX	__._%
XXXXXX	__._%	XXXXXX	__._%	XXXXXX	__._%	XXXXXX	__._%

RET

EOF

EOT

Figure 8.2.10.6-1 Classification Summary Menu

Approved: ______ NASA/DPB ______ PIIO

MENSURATION SCALING MENU

$\boxed{\text{IMD}}$

SELECT THE APPROPRIATE UNITS FOR AREA MEASUREMENT:

$\boxed{\text{SCR}}$

☐ ACRES

☐ HECTARES

☐ SQUARE KILOMETERS

EOF

ENTER THE SCALE FACTOR (UNITS/PIXEL) TO BE USED IN AREA MEASUREMENT:

$\boxed{\text{RET}}$

EOT

☐ WRITE MENSURATION RESULTS TO TAPE

$\boxed{\text{EOF}}$

$\boxed{\text{EOT}}$

Figure 8.2.10.7-1 Mensuration Scaling Menu

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8.2.12 Signature Extension Processor

8.2.12.1 Signature Extension Menu

The Signature Extension Menu (figure 8.2.12.1-1) will allow the user to checkpoint: all data, by cursoring the SIGNATURE EXTENSION TAPE CREATION box; statistics only, by cursoring the SUBCLASS STATISTICS ONLY box; or fields only, by cursoring the FIELDS ONLY box. If the user desires to write data on a specific tape, the user shall specify the tape number. The user will then have the capability to restart his run later by cursoring the SIGNATURE EXTENSION DATA RETRIEVAL box and typing the tape number of tape containing his data. For the data checks to be made, refer to paragraph 8.3.6.

LACIE use of this processor will involve reading field definitions and specific subclass information from the fields data base, and writing the same data to tape to allow for data base update. To use this processor the user should cursor the FIELDS RETRIEVAL box or FIELDS UPDATE TAPE CREATION box. When retrieving data from the fields data base, the user will have the following options:

A. Training fields of the recognition segment may be retrieved as test fields

B. Existing statistics may be retained

C. All fields may be retrieved except the test field that encloses the entire segment.

When reading from the fields data base, it will be necessary to add information to both the field and subclass names and to update line numbers for the field vertices in order to keep track of fields and subclasses belonging to different segments of the merged image. Then, when writing data base update information to tape, the reverse process must be performed. An additional problem arises, in that the interactive user may define fields across the segment boundaries; i.e., across the line values 117, 214 or 331. The program will check for this condition and riot write these field definitions to tape. Also, the user will be informed of the situation. Field name, subclass name, and field definitions will be modified as follows:

- Field names. A digit 0, 1, 2 or 3 will be added to the field name to designate whether the field belongs to the recognition segment, training segment 1, training segment 2, or training segment 3, respectively.
- Subclass Names. Again, a digit 0, 1, 2 or 3 will be added, but for subclass names to the second character of the name. Designation of the digit is as for field names.
- Field Definitions. Since the recognition segment and the training segments are merged vertically, the line numbers within the merged image are renumbered to reflect the new total size of the image and, therefore, necessitates a change in the field vertex information when the fields are read from the data base. Vertex line numbers will be updated by adding 117n to the actual line number where n is the training segment digit, 1, 2, or 3.

8.2.12.2 Signature Extension Data Display

The Signature Extension Data Display, figure 8.2.12.2-1, will be displayed, if the user has cursored the SIGNATURE EXTENSION box and typed a Signature Extension tape number. This report will allow the user to verify the contents of the Signature Extension tape. The user may continue by cursoring the CON box or cancel by cursoring the RET box.

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SIGNATURE EXTENSION

[IMD]
[SCR]

☐ SUBCLASS STATS ONLY

☐ SIGNATURE EXTENSION TAPE CREATION

TAPE ______

☐ FIELDS ONLY (INTERACTIVE MODE ONLY)

☐ SIGNATURE EXTENSION DATA RETRIEVAL

TAPE NUMBER ______

☐ CHECK HERE IF RECOGNITION SEGMENT TRAINING FIELDS CHANGED TO TEST (BATCH MODE ONLY)

☐ FIELDS RETRIEVAL

☐ CHECK HERE IF EXISTING STATS ARE TO BE RETAINED

☐ CHECK HERE IF SEGMENT TEST FIELD IS NOT TO BE RETRIEVED

[RET]

☐ FIELDS UPDATE TAPE CREATION

[EOF]
[EOT]

Figure 8.2.12.1-1 Signature Extension Menu

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8.2.13 Goodness of Fit Processor

8.2.13.1 Goodness of Fit Selection

The Goodness of Fit Processor may be selected from the Pattern Recognition processor selection menu (Figure 8.2.2.2-1), or from the Clustering Summary Report Menu (Figure 9.2.2.2-1). If the user selects the Goodness of Fit Processor from the Clustering Summary Report Menu, he must have entered G in the cancel column of that report to specify the cluster that he wishes to test for goodness of fit.

8.2.13.2 Goodness of Fit Tests Menu

When the user selects the goodness of fit processor, the menu shown in Figure 8.2.13.2-1 is displayed. This menu requests inputs of subclass or field name (not applicable if selected from the Clustering Summary Report), the channels to which the tests are to be applied and specification of either the Pearson Chi-Square Test on the Kolmogorov-Smirnov Test. If the Pearson Chi-Square Test is selected, then the user must define either the desired number of intervals with options of equally populated intervals, or a user specified number of intervals.

The report portion of the menu will be used to return a goodness of fit value and a percentile computed from the user specified test option.

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GOODNESS OF FIT TESTS

SUBCLASS OR FIELD XXXXXXX (DISREGARD IF CLUSTER)

CHANNELS [ALL]

[1] [2] [3] [4] [5] [6]

[7] [8] [9] [10] [11] [12]

[13] [14] [15] [16] [17] [18]

[19] [20] [21] [22] [23] [24]

[25] [26] [27] [28] [29] [30]

[ ] PEARSON CHI-SQUARE TEST VALUE XXXX
PERCENTILE XXX [RET]

[ ] NUMBER OF INTERVALS

[ ] EQUALLY POPULATED INTERVALS

[ ] KOLMOGOROV-SMIRNOV TEST VALUE XXXX
PERCENTILE XXX

[EOF]

[EOT]

Figure 8.2.13.2-1 Goodness of Fit Tests Menu

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8.3 PROCESSING REQUIREMENTS

8.3.1 Statistics Processor

The training fields (paragraph 8.2.3) will be the operating data base for the statistics processor which will provide:

- histograms of radiance distributions of user-selected fields and/or sublcasses is specified channels,
- field and subclass means in each channel, and all covariance matrix elements.

The histograms will be employed as analysis aids. The field and subclass means, and covariance matrix elements will be used as input data to other pattern recognition sub-processors at user discretion.

Representations of field means and covariance matrix element expressions have been selected to expedite processing efficiency. The subclass statistics expressions, derived from MSC Internal Note 72-FM-154, 5 July 1972, treat subclasses explicitly as the union of their training fields and permit ready addition or deletion of training fields without recomputing the complete subclass statistics.

In the event the SPP is online, the specifications of the SPP ICD shall be followed for the computational field statistics, fields, and imagery transmitted to the SPP for calculation. If the SPP is not online, the 360/75 shall calculate the field statistics as specified in the following paragraphs. Subclass statistics shall always be compiled by the 360/75.

8.3.1.1 Histograms

Training field definitions and the image data set will be used to display histograms of user-designated fields (and/or subclasses) in a specified channel. These displays shall indicate the percentage of elements in the region for each radiance level represented in the field (or subclass) and channel. The histogram, therefore, is the discrete distribution function of the channel data.

The capability shall exist to display one, two, or three fields and/or subclasses of histogram data simultaneously in a single channel. Requests for more than three histograms in a channel shall be accepted; the data is to be retrieved for additional fields by paging the histogram report. Histograms for more than one channel shall be requested separately.

8.3.1.2 Field Statistics

A. Field Means

For a channel i and training field f:

$$\mu_i^f = \frac{1}{N_f} \sum_{k=1}^{N_f} X_{ki}^f \qquad (1)$$

where: μ_i^f = mean of channel i data in f.

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X_{ki}^{f} = k^{th} channel i element (pixel) value in f.

N_f = number of elements in f.

Means are computed for each i in the image data set.

B. Field Covariance Matrix Elements

An element of the covariance matrix for field f represents the covariance between a pair (i,j) of channel data taken over all elements of f. These elements shall be computed:

$$\Gamma_{ij}^{f} = \frac{1}{N_f} \sum_{k=1}^{N_f} \left(X_{ki}^{f} X_{kj}^{f} \right) - \mu_i^f \mu_j^f \tag{2}$$

where:

μ_i^f = mean of channel i data in f

μ_j^f = mean of channel j data in f

N_f = number of elements in f

X_{ki}^{f} = kth channel i element (pixel) value in f

X_{kj}^{f} = kth channel j element (pixel) value in f

Γ_{ij}^{f} = the (i,j) covariance matrix element in f.

NOTE.

Since $\Gamma_{ij}^{f} = \Gamma_{ji}^{f}$, computations are to be performed only for $i \leq j$, to minimize processing.

C. Standard Deviations

The standard deviation, σ_i^f, of channel i in f is given by:

$$\sigma_i^f = \left(\Gamma_{ii}^{f} \right)^{1/2}$$

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D. Correlation Matrix

The correlation (normalized covariance) matrix element is to be computed for each covariance element for all fields:

$$\gamma_{ij}^{f} = \Gamma_{ij}^{f}/(\sigma_i^f \sigma_j^f)$$

with $i \leq j$ as in (B).

NOTE

$\gamma_{ii}^{f} = 1$ for all i.

8.3.1.3 Subclass Statistics

The following expressions for subclass means and covariance matrix elements are based on a treatment of fields as partitions of the subclass under investigation. These expressions are iterative over the fields defined for the subclass and permit extraction or incorporation of fields in a straightforward manner.

A. Subclass Means

1. addition of a field to a subclass

$$\mu_i^{[k]} = \frac{N_{[k]} - N_k}{N[k]} \mu_i^{[k-1]} + \frac{N_k}{N_{[k]}} \mu_i^{k} \tag{3}$$

where:

$\mu_i^{[k]}$ = mean of channel i data over the first k fields in the subclass.

μ_i^{k} = mean of the k^{th} field in channel i, as obtained in paragraph 8.3.1.2 A, equation (1)

$N_{[k]}$ = total number of elements in fields 1, . . ., k.

N_k = number of elements in field k.

2. deletion of fields from a subclass

The user shall have the capability to eliminate a specified training field from the subclass statistics. The following equation, subtractive form of equation (3), shall provide that capability:

$$\mu_i^{[k-1]} = \frac{N_{[k]}}{N_{[k]} - N_k} \left[\mu_i^{[k]} - \frac{N_k}{N_{[k]}} \mu_i^{k} \right]$$

(The k^{th} field is thereby removed from the subclass.)

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μ_i^k = mean of the k^{th} field in channel i, as obtained in paragraph 8.3.1.2 A, equation (1)

$N_{[k]}$ = total number of elements in fields 1, . . ., k.

N_k = number of elements in field k.

B. <u>Subclass Covariance Matrix Elements</u>

1. addition of a field to a subclass

An element, $\Gamma_{ij}^{[k]}$, of the subclass covariance matrix (for the first k fields of the class) will be computed from [k-1] term by:

$$\Gamma_{ij}^{[k]} = \frac{1}{N_{[k]}-1}\Big[\left(N_{[k]}-N_k-1\right)\Gamma_{ij}^{[k-1]} + \left(N_k-1\right)\Gamma_{ij}^{k}$$
$$+ N_k\left(\mu_i^{[k]}-\mu_i^{k}\right)\left(\mu_j^{[k]}-\mu_j^{k}\right) + \left(N_{\;k}-N_k\right)\left(\mu_i^{[k]}-\mu_i^{[k-1]}\right)\left(\mu_j^{[k]}-\mu_j^{[k-1]}\right)\Big]$$

in which each Γ_{ij}^{k} is obtained through equation (3).

2. deletion of a field from a subclass.

The subtractive form* of the equation above is to be used to establish the covariance matrix elements of the subclass following the deletion of a field k:

$$\Gamma_{ij}^{[k-1]} = \frac{N_{[k]}}{N_{[k]}-N_k}\Big[\Gamma_{ij}^{[k]} - \frac{N_k}{N_{[k]}}\Gamma_{ij}^{k} - \frac{N_k}{N_{[k]}}\left(\mu_i^{[k]}-\mu_i^{k}\right)\left(\mu_j^{[k]}-\mu_j^{k}\right)$$
$$-\frac{N_{[k]}-N_k}{N_{[k]}}\left(\mu_i^{[k]}-\mu_i^{[k-1]}\right)\left(\mu_j^{[k]}-\mu_j^{[k-1]}\right)\Big]$$

*Using the biased estimator of MSC Internal Note 72-FM-154.

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C. Standard Deviations

The standard deviation, σ_i^c, of channel i in subclass C is given by:

$$\sigma_i^c = \left(\Gamma_{ii}^c\right)^{1/2}$$

D. Correlation Matrix

The correlation matrix elements for the subclass C are to be computed:

$$\gamma_{ij}^c = \Gamma_{ij}^c / \left(\sigma_i^c \sigma_j^c\right),$$

with $i \leq j$ as in (8.3.1.2 B), $\gamma_{ii}^c \equiv 1$ for all i.

8.3.1.4 Statistics Manipulation

Statistics manipulation for sun angle correction and mean-level adjustment will be selected by the user as an operation to be performed on the subclass statistics generated in any of the user specified statistics options. These manipulations are performed to enhance the capability of extending signatures from one area that contains ground truth information to another area that does not. References in this section will be made to "reference" and "object" parameters with the "reference" pertaining to the non-groundtruth area and the "object" to the groundtruth area. That is, when the "reference" sun angle is discussed, the sun angle that is being refered to is the sun angle of the area to which signatures are to be extended. The final statistics manipulation is to be performed automatically. Subclass covariance matrices will be checked for singularity and if necessary will be manipulated as shown below.

8.3.1.4.1 Sun Angle Correction

Sun angle correction will provide the user a means for normalizing data between areas that have different sun angle elevations. A table of coefficients (α_i, β_i) versus the sun angles of the reference and object areas will be provided. There will be two coefficients, α_i and β_i for each channel with a specific sun angle, i.e., an N channel image would have 2N coefficients. The sun angle ranges of the table will be 20° to 70° in increments of 1°. The coefficient α_i will have a decimal value X.XXX varying between 0 and 5.000 and β_i a decimal value XX.XX varying between -100 and 100. After the coefficient values have been determined, the subclass statistics will be corrected as follows:

$$\mu_i^{c'} = \alpha_i \cdot \mu_i^c + \beta_i \qquad (1)$$

where:

$\mu_i^{c'}$ = The corrected mean in channel of the C^{th} subclass

α_i = 1st correction coefficient for channel i corresponding to ζ_r and ζ_o

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ζ_r, ζ_o = sun angles of the reference (r) and object (0) images

μ_i^c = mean in channel i of the C^{th} subclass

β_i = 2^{nd} correction coefficient for channel i corresponding to ζ_r and ζ_o

The subclass covariance is then:

$$\Gamma_{ij}^{c'} = \Gamma_{ij}^{c} \, a_i \, a_j \qquad (2)$$

where:

Γ_{ij}^{c} = the element of the covariance matrix for the C^{th} subclass representing the relationship between a pair (i,j) of channel data

$\Gamma_{ij}^{c'}$ = the corrected Γ_{ij}^{c}

a_i = correction coefficient for channel i corresponding to ζ_r and ζ_o

a_j = As a_i but for channel j

8.3.1.4.2 Mean Level Adjustment

The means are to be computed in the reference area and in the object area for the mean-level adjustment fields. If sun angle correction was performed, the means will be corrected as in the Paragraph 8.3.1.4.1. Then mean-level adjustment will be done as follows:

$$\Delta\mu_i = \mu_i^o - \mu_i^r \qquad (3)$$

where:

μ_i^o = mean over the MLA fields in the object area for channel i

μ_i^r = as μ_i^o but for reference area

The mean will then be adjusted for each subclass statistic as:

$$\mu_i^c = \mu_i^c - \Delta\mu_i$$

where:

μ_i^c, μ_i^c and $\Delta\mu_i$ are as before.

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8.3.1.4.3 Covariance Singularity Adjustment

During further processing the generated subclass covariance matrices must be inverted. If because of singularity conditions a matrix cannot be inverted, the matrix will be modified according to the following rule:

$$\Gamma_{ij}^{c'} = \Gamma_{ij}^{c} + EI \tag{4}$$

where:

Γ_{ij}^{c} = subclass covariance matrix to be modified

E = a constant value 0.1

I = the identity matrix

$\Gamma_{ij}^{c'}$ = the modified subclass covariance matrix

This modification will be repeated a maximum of five times. The user will be notified of the number of modifications required. Also, if five attempts do not correct the singularity, the job will be aborted and the user notified.

8.3.1.5 Bhattacharyya Chaining Processor

The Bhattacharyya distance (B-distance) function is discussed in Paragraph 8.3.2.2.1 as applied to the Feature Selection Processor and referenced in other sections of this document. The application of this distance function in this case is to chain fields of the same class that contain a number of subclasses. Therefore the chaining processor will chain subclasses of a class into a different group of subclasses as follows:

Intraclass B-distance

$$H[ij, ik] = \exp\left[-\frac{1}{4}\delta_{jk}^{T}(\Gamma_{ij} + \Gamma_{ik})^{-1}\delta_{jk} - \frac{1}{2}\ln\left(\frac{|\Gamma_{ij} + \Gamma_{ik}|}{2^{n}\,|\Gamma_{ij}|^{1/2}\,|\Gamma_{ik}|^{1/2}}\right)\right]$$

where:

i = class identifier

j, k = subclass identifiers

$\delta_{jk} = \mu_{ij} - \mu_{ik}$, subclass means

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Γ_{ij}, Γ_{ik} = subclass covariance matrices

$| \;\; |$ = determinant function

n = number of channels

then if, $H[ij, ik] > 0.5$, combine the statistics of the two fields/subclasses into one field/subclass.

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8.3.2 Feature Selection Processors

The objective of the feature selection applications is the reduction of the channel dimensionality of an image from N to k<N. The k coordinates represent either a proper subset or linear combinations of the original channel set. The function performed in any of these processors is the elimination from consideration of those channels in which little or no definition between the defined classes can be made.

Two separability measures and three channel search procedures are to be provided in accordance with the controls identified in Paragraph 8.2.7 and with the requirements below.

8.3.2.1 Divergence Processor (Exhaustive Search)

The divergence processor will provide a user capability to select a "best" channel set to be used in the classification process. The divergence process involves the use of a methodology to measure the degree of statistical separability of the probability distributions of each of the classes. The output results (output format is described in paragraph 8.4.4.4) is a list of the "best" sets of channels to be utilized in the classification of the data into the subclasses chosen, minimizing the probability of misclassification.

8.3.2.1.1 Inputs To The Divergence Processor

The following are inputs needed to compute the best set of channels (spectral bands) to be used for maximum separability (divergence).

A. Channels. The channels not to be considered in selecting the optimum set of channels for maximum spearability. The default will be all channels. The maximum number of channels to be considered will not exceed 30.

B. Channel Set Size. The number of channels in a selected set. Maximum channel set size will be eight. The default will be four channels.

C. Subclasses. The subclasses for which optimum separability is to be determined. These must be input. Each subclass will have been given a character name.

D. Weighting Factors. Weight to be applied to a particular pair of subclasses in determining average divergence. This will be a value from 0-10 (10 is the default).

E. D(MAX) Maximum value of pairwise divergence. If a computed weighted pairwise divergence exceeds this value, the pairwise divergence is assigned the D(MAX) value. (Default is 999)

F. D(MIN) Minimum value of pairwise divergence. If a computed pairwise divergence falls below this value for a channel set, the set is not considered.

G. Ranking. Method to be used to rank the best channel sets; i.e., D(AVE), D(MIN) or user specified subclass pair, D(I,J)

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8.3.2.1.2 Divergence Processor Computations

8.3.2.1.2.1 Divergence

The divergence between the C^{th} and K^{th} subclasses given a set of up to 30 channels is defined as:

$$D_{ck} = \sum_{i=1}^{N} \sum_{j=1}^{N} \left(\Gamma_{ij}^{c} - \Gamma_{ij}^{k}\right) \cdot \left(\Gamma_{ij}^{-k} - \Gamma_{ij}^{-c}\right) + \sum_{i=1}^{N}\sum_{j=1}^{N} \left(\Gamma_{ij}^{-k} + \Gamma_{ij}^{-c}\right) \cdot \Delta_i \cdot \Delta_j$$

where:

N = channel set size (maximum 8, default 4)

Γ_{ij}^{c} = the element of the covariance matrix for the C^{th} subclass representing the relationship between a pair (i,j) of channel data.

covariance matrix for subclass C

$\Gamma_{i,j}^{-c}$ = the (i,j) element of the matrix inverse of Γ^{c}

$\Delta_i = \mu_i^c - \mu_i^k$.

μ_i^c = mean in channel i of subclass C^{th}

8.3.2.1.2.2 Transformed Divergence

The transformed divergence between the C^{th} and K^{th} subclasses will then be computed from the divergence, D_{ck}, as:

$$T_{ck} = 999 \left[1 - \exp\left(-D_{ck} / 16\right)\right]$$

8.3.2.1.2.3 Weighted Divergence

Then the weighted divergence between the C^{th} and K^{th} subclasses will be computed from the transformed divergence, T_{ck}, as:

$$W_{ck} = W \cdot T_{ck}/10.0$$

where:

W = the user designated weight for the subclass pair, (c,k)

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8.3.2.1.2.4 Average Divergence

The average divergence will be computed as the average of all weighted subclass-pair divergences, W_{ck}, for a particular channel set, N.

$$D(AVE)_{c,k} = \frac{2}{M(M-1)} \sum_{i=1}^{M-1} \sum_{j=i+1}^{M} W_{c,k}$$

where:

M = the total number of considered subclasses

8.3.2.2 Bhattacharyya Distance Functions

The three optional uses of the B-distance measure are shown in Figure 8.2.7-1. All three require the computation of a total separability measure on all identified channels under several input controls:

A. Channels. The channels not to be considered in selecting the optimum set of channels for maximum separability. The maximum number of channels to be considered will not exceed 16.

B. Subclasses. The subclasses must be input for which optimum separability is to be determined.

C. Excluded Separability Subclass Set. A set of subclasses to be subject to no intraclass or interclass separability computation among themselves in the calcation of a total separability measure. These must be input.

D. A Priori Category Values. A set of input values indicating a bias to be made to each category weighting on the basis of prior information.

In the case of the Without Replacement and Iterator Options, the following two additional inputs may be made:

E. Separability Criterion. A value between 0 and 1 indicating the requirements on a channel subset separability in terms of a ratio between such a separability and an ALL CHANNELS total separability. This value is defaulted to 0.900.

F. Channel Set. A number of channels between 3 and 16 to be generated by the iterator as linear combinations of the original channel set. If defaulted, this value is determined on the basis of the smallest without replacement channel set satisfying the separability criterion of subparagraph E above.

8.3.2.2.1 B-Distance Separability

The distance measure employed is an exponential expression of the Bhattacharyya distance function, herein designated B-distance; the exponential form is such that, although monotonic, the function diminishes as the Euclidian distance measure increases.

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The structure of the equations below is predicated on the assumptions that the defined classes are of two types: a set of classes π_1 to π_X (see paragraph 8.2.7.4.1) with respect to which several measures of internal and mutual separability are of interest, and a set of classes π_{X+1} to π_Y (all other classes) for which distinction is not necessary or critical in the same sense as for the $\pi_1, \ldots, \pi_X$, and further that each class π_i ($i=1, \ldots, y$) may be composed of one or more subclasses π_{ij} ($j=1, \ldots, j_i$), for which class (subclass) statistics are defined.

The expressions below are to be calculated for each image entering the B-distance feature selection processors with a set of subclass statistics defined in the indicated manner. The same expressions are employed in subsequent paragraphs for channel subsets or linear combinations.

- B-distance:

$$H[ij,\ kl] = \exp\left[-\frac{1}{4}\delta_{jl}^{T}\left(\Gamma_{ij} + \Gamma_{kl}\right)^{-1}\delta_{jl} - \frac{1}{2}\ln\left(\frac{\left|\Gamma_{ij} + \Gamma_{kl}\right|}{2^{n}\left|\Gamma_{ij}\right|^{1/2}\left|\Gamma_{kl}\right|^{1/2}}\right)\right] \qquad (1)$$

where:

i, k are distinct classes (k,i may be equal)

j, l are subclass identifiers for i, k respectively

$\delta_{jl} = \mu_{ij} - \mu_{kl}$ as previously defined, an Nxl matrix

Γ_{ij}, Γ_{kl} are the covariance matrices for subclasses ij, kl

$\left|\Gamma_{ij}\right|$ is the determinant of Γ_{ij}

The B-distance is to be calculated over all channels N of the statistics under the following limits on i, j, k. l:

$i = 1, \ldots, Y$

$j = 1, \ldots, j_i$

$k = i, \ldots, Y$

$$\begin{cases} l = 1, \ldots, l_k \text{ when } i \neq k \\ l = j+1, \ldots, l_k \text{ when } i = k \end{cases}$$

- Distance flag

Subclasses having undesirable distance measures from other subclasses of the same class shall be flagged for output to report; this flag is established when:

$$H[ij,\ kl] < 0.5 \qquad (2)$$

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8.3.2.2.4 Image Transformations

The output of the linear combinations procedure is a k x N matrix, B, to be applied to each pixel of the object segment for creation of (1) a film product, where k=1 or k=3, and/or (2) a k dimensional image suitable for operations by the classification algorithm.

The transformation is

$$Y = BX$$

where X is the Nxl input measurement vector and Y is the Kxl output measurement vector.

The statistics used will be those related to the classification subclasses designated by the user. An error should be returned if the respective statistics have not been computed.

8.3.2.2.5 Statistics Transformations

A rotated set of subclass statistics is to be obtained and employed by the classification processor when the linear combinations option has been exercised. This set of statistics shall replace the existing subclass statistics.

Using previous notation, the following values are to be calculated for each subclass for which statistics are defined.

$$\mu_{ij} = B\mu_{ij}$$

and $\Gamma_{ij} = B\Gamma_{ij}\ B^T$

where:

$$i = 1, \ldots, X$$

$$j = 1, \ldots, j_i$$

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8.3.3 Classification Processor

The Classification Processor will provide the user with the final desired result of the pattern recognition processor; i.e., the classifying of each pixel of a designated field(s) into one of the specified training subclasses. The final assignment is made by evaluating the maximum likelihood equation shown below for each of the measurement vectors of the designated field(s) and assigning the pixel to the subclass that yields the maximum probability that the element belongs to that subclass.

The Classification Processor shall prepare the parameters defined below for transmission to the SPP, as defined in the SPP ICD, when the SPP is online. If the SPP is not online, the requirements of the following paragraphs shall be performed by the pattern recognition application internal to the 360/75.

8.3.3.1 Inputs To The Classification Processor

To initiate the classification of the image being processed, the following input parameters must be specified.

A. Classification Subclasses. The individual subclasses into which the data is to be classified.

B. Class/Category Specification. The categories that are to be classified only to the class level.

C. Classification Channels. The channels to be used to classify each element of the image.

D. Classification Area. The portion of the image which is to be classified. This is designated by specifying the field names to be classified.

E. User specified a priori constants for each category. The processor will default to equal probability for all categories: i.e., the a priori values ρ_c as normally input will be 100/C, where C is the number of categories into which the data is to be classified. Possible inputs permitted for a priori specification are:

   1. Value for all classes and $\Sigma\rho_c = 100$. The value used for the classification likelihood equation will be $\rho c/100$ for the appropriate Cth class.

   2. Value for a subset of classes but $\Sigma\rho_c = 100$. The value used for the classification likelihood equation will be $\rho_c/100$ for the appropriate Cth class, however classes with no inputs will not be considered.

   3. Value for a subset of classes and $\Sigma\rho_c < 100$. The value used for the classification likelihood equation will be $\rho_c/100$ for the appropriate Cth class, however the remainder of the classes will be assigned a value of $(100 - \Sigma\rho_c)/100C$; i.e., the remainder of the classes will assume equal probability of the remainder of the sumation.

   4. Value for a subset of classes or for all classes but $\Sigma\rho_c > 100$. The value to be used when the summation is greater than 100 will be $\rho_c/\Sigma\rho_c$. If values were input for only a subset of classes, the classes which had no input will not be considered.

   5. Category input of a priori values will be handled as in items 1 through 4, but will then be assigned equally over the class and subclass divisions; i.e., the ρ_c as computed above will be assigned the value ρ_c/MN for each subclass of the category, where M and N are the number of classes and the number of subclasses, respectively, in the category. This computation is performed only when utilizing the mixture density function classifier described in Paragraph 8.3.3.3.

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8.3.3.2 Maximum Likelihood Classification Computation

Each pixel of the field(s) to be classified will have a classification likelihood value (H_C) and a subclass (C) assigned to it. An H_c is computed for each subclass for each pixel and the pixel is assigned to the subclass which yields the H_c that provides the minimum probability of misclassification. The classification likelihood value is computed and used in the subclass decision making. The chi-square form of the value is extracted, transformed to an eight-bit integer and stored, i.e., accurate to about 1/2 of one percent for use by the display processor. The formulation for this process is as follows:

$$H_c = S_c + \sum_{i=1}^{N} \sigma_i \sum_{j=1}^{i} \Gamma_{ij}^{-c} \cdot \sigma_j \tag{1}$$

where:

$S_c = (R_c - P_c)$

$R_c = 1/2 \ln \left| \Gamma_{ij}^{c} \right|$

$P_c = \ln \rho_c$

Γ_{ij}^{c} = the element of the covariance matrix for the C^{th} subclass representing the relationship between a pair (i,j) of channel data:

$\left| \Gamma_{ij}^{c} \right|$ = the determinant of Γ_{ij}^{c}

Γ_{ij}^{-c} = the matrix inverse of Γ_{ij}^{c}

ρ_c = a priori constant for the C^{th} subclass

$\sigma_i = \left(X_i - \mu_i^{c} \right)$

X_i = measurement vector in channel i

μ_i^{c} = mean in channel i of the C^{th} subclass

The measurement vector, X_i, is then assigned to the subclass, C, for which:

$$H_c < H_k \text{ for all } K \neq C \tag{2}$$

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8.3.4 Display Processor

8.3.4.1 Display Processor Inputs

The Display Processor displays classification results for an image which has been classified. The following are necessary input for the display processor.

1. Desired mapping option. Options include color map, gray level map, character map (microfiche) and image tape.
2. Color values, gray level values, class characters and colors and intensities for image tapes.
3. User threshold values
4. Mensuration constants.

8.3.4.2 Display Processor Computations

The following computations will need to be made to implement the display processor:

A. Threshold Option. The user will specify a threshold percentage that the processor will utilize to look up in a table (ILIKE values versus percentages) an appropriate ILIKE value to be used to determine the null subclass. Zero percent will correspond to an ILIKE of 255 and 100 percent to zero ILIKE. Then for any classified pixel that has an I value (Paragraph 8.3.3.2) that falls above the ILIKE value, the null subclass will be assigned to that pixel for display purposes. Therefore, a threshold of zero percent (ILIKE=255) would cause no pixels to be assigned to the null subclass and a threshold of 100% would cause all pixels to be assigned to the null subclass.

B. Percentage. Simple percentages will need to be computed (no. sample X 100 percent/total no. sample for training and test fields. LACIE recognition segment percentages will be biased to account for designated unidentifiable (DU) fields as follows:

$$\% = \frac{\text{No. of samples}}{\text{Total no. of samples - DU}} \times 100$$

C. Mensuration. If the mensuration option is selected, the display processor will need to multiply the number of samples classified into each class by the appropriate constant.

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8.3.4.3 Display Processor Outputs

The display processor will output many types of display output.

A. The Classification Map. The designated portion of the classified image will be output. Each element will be represented by a symbol, color or gray level associated with the subclass that the element has been classified into.

B. Performance Tables. One line will be output for each field (training or test) plus one line for a set of totals for each type of field. Each line of data will contain the following:

1. Field ID

2. Subclass

3. Total number of samples in field or group

4. The percentage of the samples classified correctly into the subclass assigned to the field or group is also output.

5. Total number of samples classified into each group (a null group is added if a threshold was input).

C. Mensuration Tables. Mensuration output will contain the same information as listed for the performance tables, except that instead of number of samples output a mensuration value is output.

D. CAS Interface Tape. A CAS interface tape will be output that contains the information as described in paragraph 8.4.4.7.

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8.3.6 Signature Extension Processor

8.3.6.1 Fields Only

The Signature Extension Processor can checkpoint only fields at the user's request. When the Signature Extension option is specified, the program will only check the boundaries of the loaded image for inclusion of all checkpointed fields and not the number or compatibility of channels.

8.3.6.2 Statistics Only

The user may opt to checkpoint subclass statistics only at checkpoint time. Then when the Signature Extension option is selected, the program will only check compatibility of the channel configuration of the loaded image and not the boundaries.

8.3.6.3 Fields and Statistics

The program Signature Extension logic will have to check both the channel configuration and the boundaries of the loaded image when the user has elected to checkpoint both fields and statistics. All of the options, Fields Only, Statistics Only, and Fields and Statistics, require the storing of Signature Extension data in order that all Pattern Recognition Processors can access the data for further processing.

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8.3.7 Goodness of Fit Processor

8.3.7.1 Inputs to the Goodness of Fit Processor

The following user inputs are required to initiate the Goodness of Fit Processor.

A. The subclass, field, or cluster to be tested.

B. Channels of the subclass, field, or cluster to be used.

C. Test to be performed, i.e., Pearson Chi-Square or Komolgorov Smirnov Test.

D. Statistics of field, subclass, or cluster.

E. Intervals, if the Pearson Chi-Square Test is selected.

8.3.7.2 Pearson Chi-Square Test

Using μ_i and Γ_{ij} computed from the Statistics Processor or clustering application form compute:

$$Q = \sum_{i=1}^{N} \sigma_i \sum_{j=1}^{i} \Gamma_{ij}^{-1} \sigma_i$$

for the collection of data points to be analyzed.

where:

N = number of channels

$\sigma_i = (\chi_i - \mu_i)$

χ_i = measurement vector in channel i

Γ_{ij}^{-1} = covariance of the field, subclass, or cluster to be tested.

Then apply the Pearson Chi-Square Goodness of Fit Test to the chi-squared distribution of Q values as follows:

A. Fix number of intervals, K, for partition of Q values

B. Fix interval endpoints based upon

1. Equidistant intervals or,
2. Equally populated intervals.

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C. Partition the Q values for each interval to determine the theoretical population, P_{Ti}, and observed population, P_{oi}.

D. Then form:

$$G = \sum_{i=1}^{K} \frac{(P_{oi} - P_{Ti})^2}{P_{Ti}}$$

E. Output the value of G and its percentile in the chi-squared distribution for K-1 degress of freedom.

8.3.7.3 Kolmogorow-Smirnov Test

From the chi-squared distribution of Q values, Paragraph 8.3.7.2, apply the Kolmogorow-Smirnov Goodness of Fit as follows

A. Find $L_i = \int_{o}^{Q_i} \chi_n^2 \; d\,\chi_n^2$

where: i = 1, 2, 3 ...N intervals

B. Find $K_i = \max \left[\left| L_i - \frac{i}{n} \right|, \left| L_i - \frac{i-1}{n} \right| \right]$

C. Output $K_{max} = \max\ [K_i]$

D. Output percentile equals:

$$2 \sum_{j=1} (-1)^{j+1} \; \epsilon^{2j^2} \; N^2 \; K_{max}^2$$

For more information concerning both goddness of fit algorithms see NASA JSC Internal Note 73-FM-63, dated May 4, 1973.

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8.3.8 Batch Input Processor

8.3.8.1 Processor Inputs

The Batch Input Processor reads records from the Process Control Data Base to build the corresponding menu inputs that are used to process the Process Control Data Base data. For the Process Control Data Base inputs, refer to paragraph 4.8.2.

8.3.8.2 Processing Flow

Since options such as sun angle correction (SAC) and mean level adjustment (MLA) of the subclass statistics are available, care must be taken to use the proper statistics in classification of the sample segments of a merged LACIE image. The data processing flow diagram (figure 8.3.8.2-1) illustrates the processing flow required to assure data processing integrity. The flow diagram also includes all options associated with the data processing. The following steps make up the complete data flow.

A. Image Merge. Retrieve recognition segments merged with associated training segments (up to three training segments). The number of training segments is used to define the constant K. If no external statistics are given, go to the Fields Retrieval step.

B. External Statistics. Retrieve external statistics from a user specified tape and pass on to the Statistics Report step. External Statistics step is optional.

C. Fields Retrieval. Retrieve field definitions from the fields data base.

D. Normal Statistics. Compute the statistics for all training fields.

E. Cluster/Chaining. Perform the clustering and chaining as specified by the process control input cards.

F. Store Statistics. Store resultant statistics for later use.

G. SAC/MLA. Perform the sun angle correction and the mean level adjustment as specified by the process control input card. Output the results as a statistics report. Note, the SAC and MLA performed in this step is to correct the subclass statistics "from" the training segments "to" the recognition segment.

H. Statistics Tape. Produce a statistics tape from the SAC/MLA output, if requested.

I. Statistics Report. Produce a statistics report from the statistics computations or from the external statistics from the External Statistics, step B.

J. Feature Selection. Perform feature selection.

K. Classify RSEG. Classify the recognition segment.

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L. Classification Output. Output a classification map, summary, and CAS interface tape.

M. Mensuration. Perform mensuration and output to mensuration data base.

NOTE

The following steps are the steps in the training segment classification loop that correct the subclass statistics to the specific training segment classified.

N. If $K \neq O$. η is set to 1. If K is not equal O, proceed to Retrieve Statistics. If K equals O, exit.

O. Retrieve Statistics. Retrieve statistics from step F. If SAC and MLA are not require go to Classification TSEGη, step R.

P. SAC/MLA. Perform SAC and MLA to the training segment to be classified.

Q. Statistics Report. Produce a statistics report.

R. Classify TSEGη. Classify the training segment with the statistics of step P or from the Retrieve Statistics, step O.

S. Classification Output. Output classification summary and a CAS interface tape from the Classify TSEGη step.

T. η=K. If η equals K exit. If η does not equal K increment η by 1 and go to Retrieve Statistics, step O. Steps O through T will be repeated until η equals K, which means all training segments have been processed.

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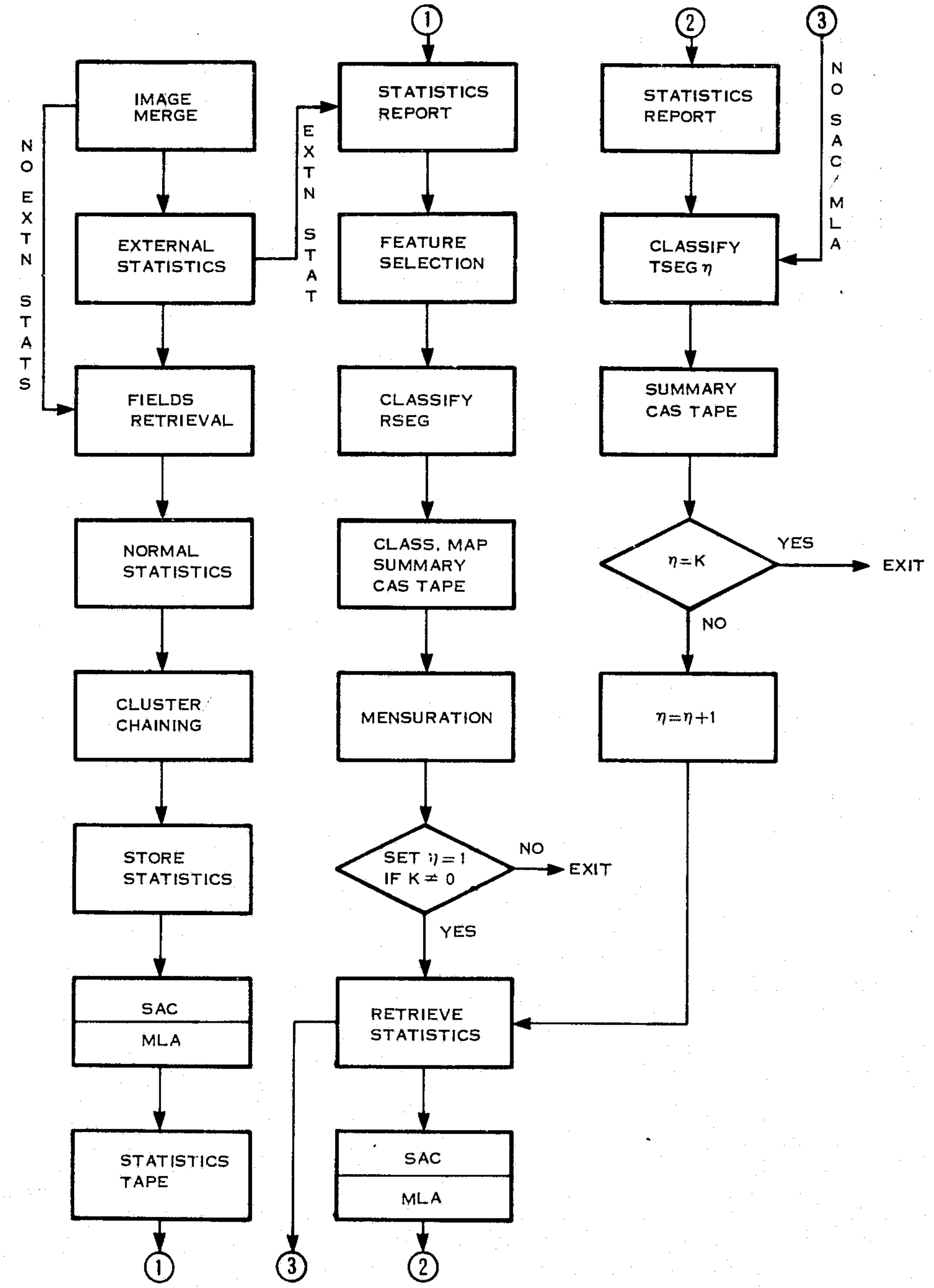

Figure 8.3.8.2-1 Data Processing Flow Diagram

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8.4 OUTPUTS

8.4.1 General

This section describes the outputs of the Pattern Recognition program in the areas of imagery, graphic data and digital data. The imagery displays will appear on the imagery television screen in 16 levels of gray and/or on the color television screen, while the graphic data and digital data will appear on the conversational television screen in black and white. All reports will be made available for display as requested by the user. In addition, all reports will be available for retrieval upon request under the following conditions:

A. The user has not exited the applications program that computed the display; i.e., pattern recognition.

B. New data has not been requested by the user; i.e., if new training regions have been defined and statistics data recomputed, then the previous statistics data is no longer available.

The Batch Input Processor will automatically output the following reports to a microfiche outpout tape.

- Image Merge Report
- Fields Report
- Statistics Report (output when all statistics manipulations have been completed)
- Bhattacharyya Chaining Report
- Classification Summary Report

Also, a classification image consistent with the requirements described in paragraph 8.2.9.6 will be output for each classification run. An additional output will be a Crop Assessment Subsystem (CAS) interface tape, refer to paragraph 8.4.4.6.

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8.4.2 Imagery

8.4.2.1 Graymaps

Graymaps may be used for two purposes during pattern recognition processing:

A. Initially for the user's visual inspection and training field(s) definition and

B. For the final classification map.

8.4.2.2 Initial Graymaps

The graymap for the initial training field(s) definition will be generated by the Image Manipulation and Display Processor using one of the gray level determination methods of Paragraph 6.3.3.

8.4.2.3 Classification Maps

Classification maps may be generated on the 16 levels of gray television screen, on the 64 color television screen, as a character map to microfiche, or as an image tape. The user will have the option of specifying gray levels and colors or using a computer default set. If the user opts to have the classification printed he must enter the symbols to be used for the subclasses. The Subclass map will depict visually the correspondence between the class membership and spatial location of any given pixel in the image. Classified Fields may be displayed simultaneously in proper geographic context relative to the overall image. See Figure 8.4.2.3-1.

Approved: TGP NASA/DPB RWS PHO

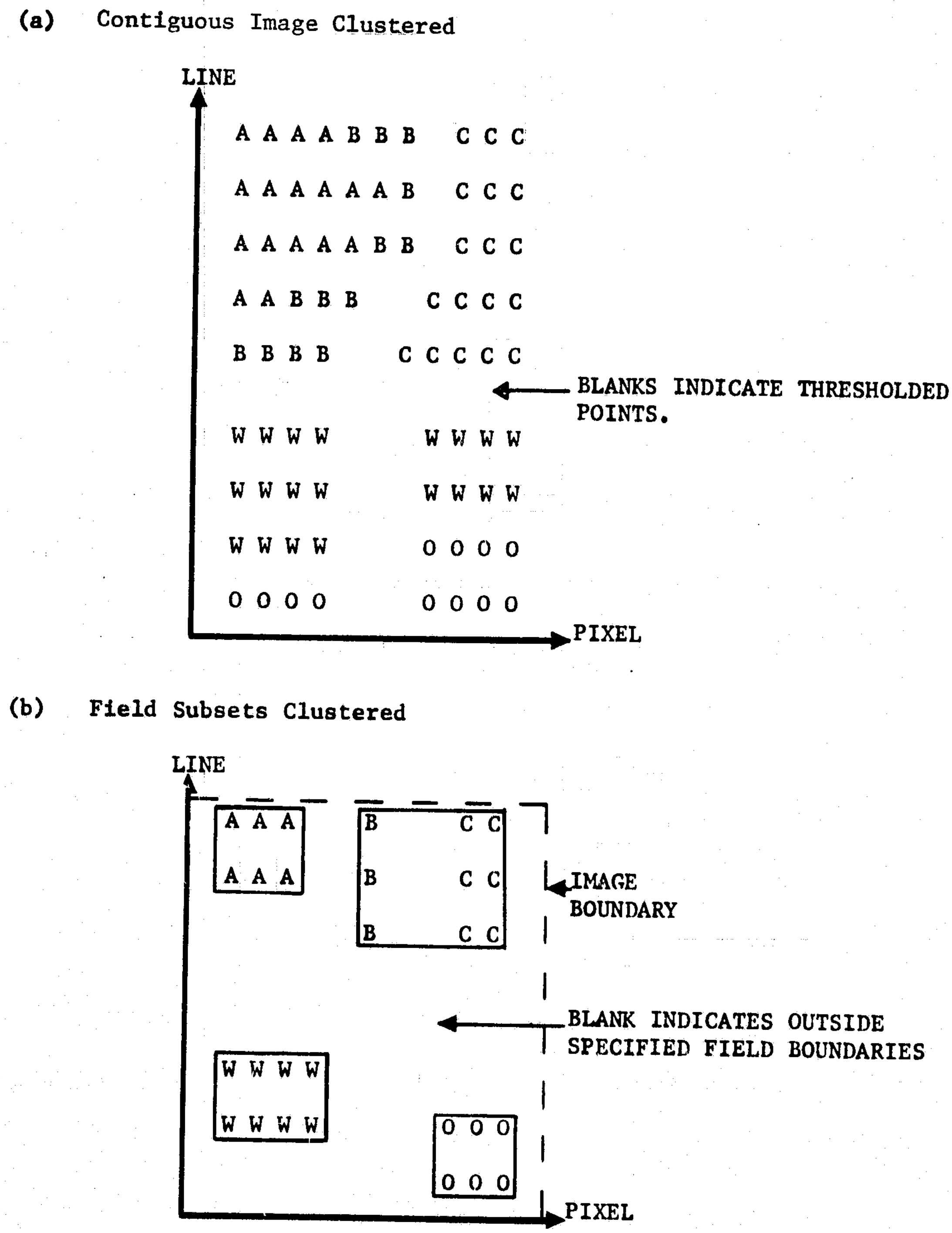

Figure 8.4.2.3-1 Illustration of Class Maps (Character Option)

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8.4.3 Graphic Data

8.4.3.1 Histogram Plots

Histogram plots will be displayed on the conversational television screen upon request to determine the validity of the Gaussian distribution assumption. The histogram plots will express the percentage (maximum scale of 50 percent) of total elements of a training field for a group of training fields (subclass) versus a particular relative radiance as a line graph. The relative radiance scale will increase to the right regardless of the direction of increasing brightness. There will be up to four histogram line graphs per plot for up to four subclasses and one channel. If the user has elected to expand (i.e., blow up or specify the scaling) this plot, an indicator with the percentage of total points under all four curves that is outside the scale will be displayed. Also, the total number of points in each subclass will be listed with the subclass name. An example of the histogram plot is shown in Figure 8.4.3.1-1. There will be Reseau Marks on the histogram plot to aid visual interpolation accuracy. If the amount of data required to display four histogram line graphs results in an overflow condition, the user will be notified and requested to specify fewer histograms.

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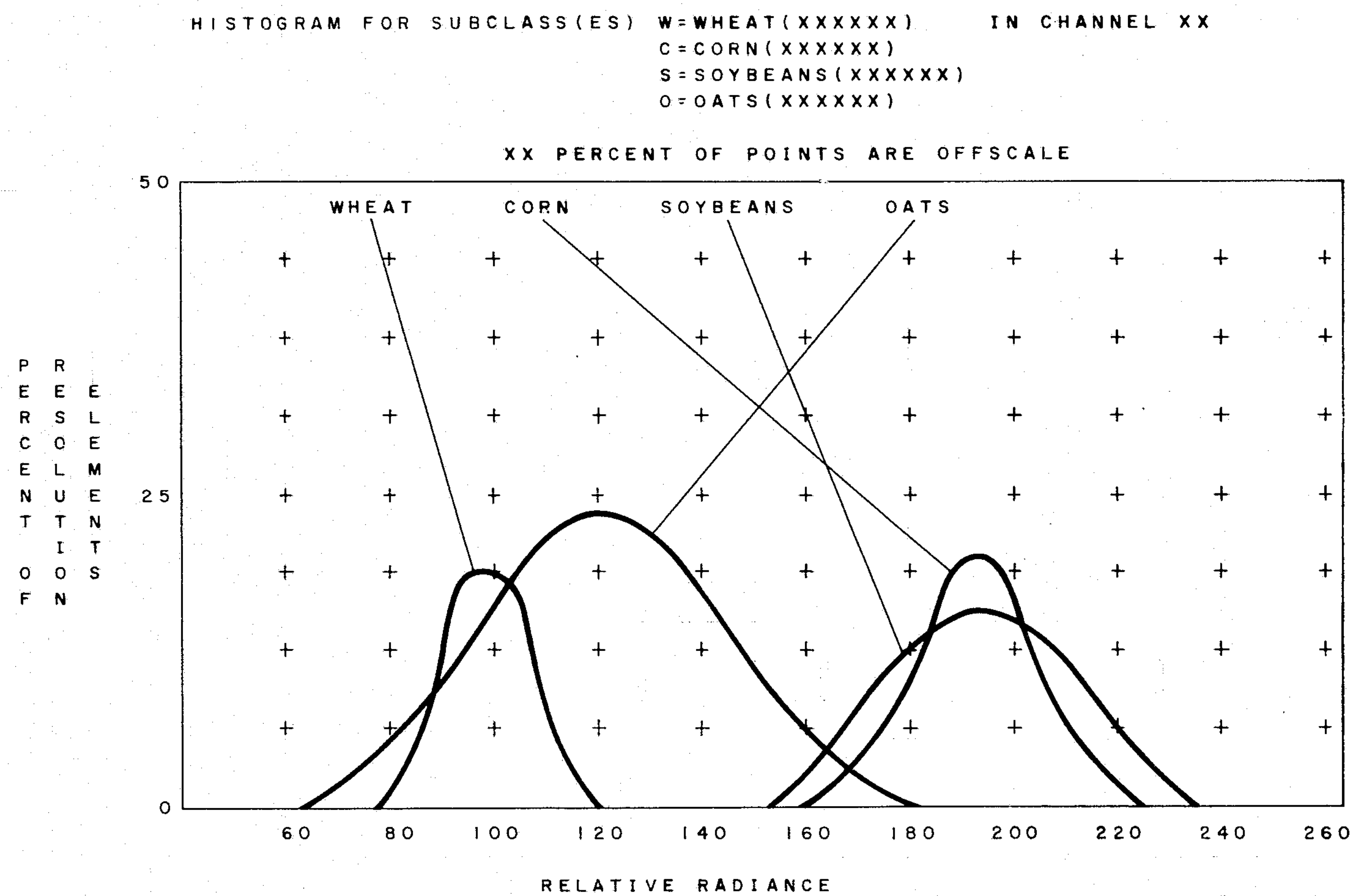

Figure 8.4.3.1-1 Histogram for Subclasses

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8.4.4 Digital Data

8.4.4.1 Field Definition Display

The user may request at any time during processing a display of the field definitions (training fields, test fields or any miscellaneous fields). A sample of this output is shown in Figure 8.4.4.1-1. The columns of data will list the field ID and subclass, the type of field (training, test, other) as a symbol, the category symbol and the vertices (up to 10) of the fields. The vertices will be defined by line and column numbers. A page capability will exist to allow observation of all field definitions.

In addition to the field definition report, an annotation page shall be output when the fields have been retrieved from the fields data base. This page will reflect the current status of the fields for the recognition segment and all training segments being analyzed. The format of this report is shown in Figure 8.4.4.1-2.

8.4.4.2 Mean-Standard Deviation

A request to view the computed means and standard deviations will result in a report on the conversational television screen as illustrated in Figure 8.4.4.2-1. The channels will be listed in the first column with the means and standard deviations in each of the channels for up to four subclasses or training fields listed in columns to the right of the channels. The total number of elements in each subclass or field will be listed under the subclass or field name. In the field columns the subclass name to which the field belongs will be listed under the number of elements in the field. The user will have the option with this report to view all subclasses, all training fields or both. When requesting data for more than four subclasses and/or training fields the user will have the capability to page to observe the complete set of data. For each set of subclass statistics, the statistics manipulations performed to arrive at that set of statistics will be shown. The possibilities are normal statistics, clustering, chaining, sun angle correction, mean level adjustment, and combining.

8.4.4.3 Feature Select Reports

8.4.4.3.1 Divergence Processor Displays

In order to compact the display of the best channel sets and the interclass divergence values, the first display available to the user from the divergence processor will be the list of the 30 best channel sets as determined by the divergence processor (see Figure 8.4.4.3-1). If any user-specified channel sets are contained in the best 30 channel sets, they will be flagged with an asterisk, see ranking No. 10 in Figure 8.4.4.3-1.

Following the Best 30 Channel Sets will be the detailed interclass divergence values for all 30 sets in Figures 8.4.4.3-2, 8.4.4.3-3, and 8.4.4.3-4. The user will have the capability to page and observe interclass divergences for all class pairs.

If the user has specified any special channel sets, the sets will be listed as the last entries in the top 30 best sets, and if they appear in the 30 best sets marked with an Asterisk and not repeated; i.e., if the user specifies five sets they would appear in position 26 to 30 unless one or more were included in the top thirty.

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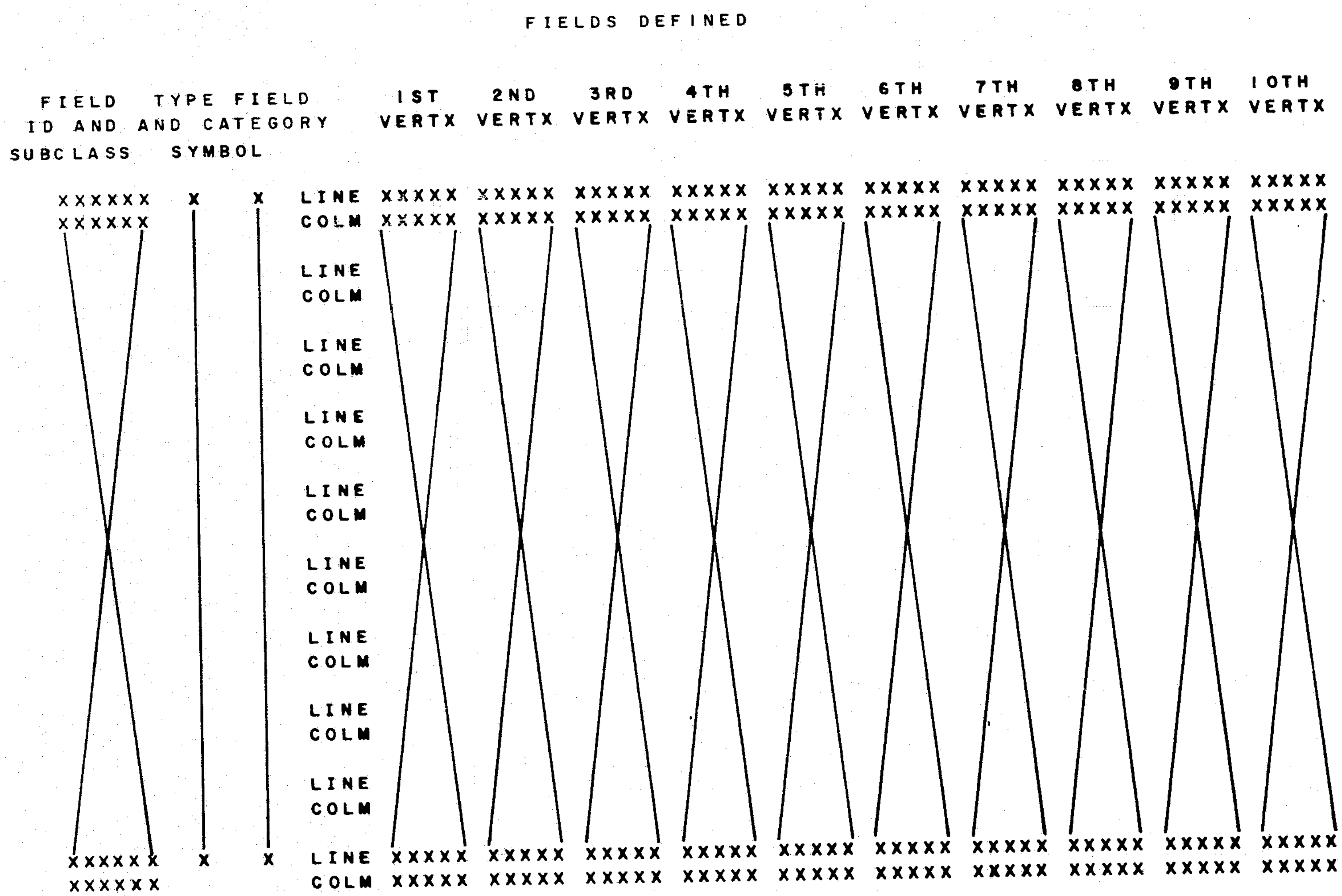

Figure 8.4.4.1-1 Training Region Display

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FIELD DEFINITION REPORT

ANNOTATION PAGE

* THE FIELDS LISTED IN THE REPORT WERE RETRIEVED FROM THE FIELDS DATA BASE.

* THE SEGMENTS CONTAINING THE FIELDS ARE LISTED BELOW.

SEGMENT ACTIVITY JOURNAL

	SITE ID	USER ID	DATE OF LAST UPDATE
RSEG	XXXX	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXX
TSEG1			
TSEG2			
TSEG3	XXXX	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXX

Figure 8.4.4.1-2 Field Definition Report

Approved: ______ NASA/DPB ______ PHO

```
                         MEAN AND STANDARD DEVIATION
                       FOR CLASSES AND TRAINING FIELDS
                              AND ALL CHANNELS
            CLASS XXXXXX     CLASS XXXXXX     CLASS XXXXXX     FIELD XXXXXX
             (XXXXXX)         (XXXXXX)         (XXXXXX)         (XXXXXX)
CHANNEL                                                        CLASS XXXXXX
NUMBER      MEAN  ST DEV     MEAN  ST DEV     MEAN  ST DEV     MEAN  ST DEV

   1       XXX.XX  XX.XX    XXX.XX  XX.XX    XXX.XX  XX.XX    XXX.XX  XX.XX
   2
   3
   4
   5
   6
   7
   8
   9
  10
  11
  12
  13
  14
  15
  16
  17
  18
  19
  20
  21
  22
  23
  24
  25
  26
  27
  28
  29
  30       XXX.XX  XX.XX    XXX.XX  XX.XX    XXX.XX  XX.XX    XXX.XX  XX.XX
```

Figure 8.4.4.2-1 Mean and Standard Deviations

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```
        COMPUTED BEST CHANNEL SETS
      WITH RANKING BASED ON D(AVE)

    1.  XX,XX,XX,XX,XX,XX,XX,XX
    2.
    3.
    4.
    5.
    6.
    7.
    8.
    9.
*  10.
   11.
   12.
   13.
   14.
   15.
   16.
   17.
   18.
   19.
   20.
   21.
   22.
   23.
   24.
   25.
   26.
   27.
   28.
   29.
   30. XX,XX,XX,XX,XX,XX,XX,XX
```

Figure 8.4.4.3-1 Computed Best Channel Sets

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MINIMUM=XXX | INTERCLASS DIVERGENCE TABLE | MAXIMUM=XXX

WITH RANKING BASED ON D(AVE)

BEST SPECTRAL BAND SETS

	1.	2.	3.	4.	5.	6.	7.	8.	9	*10.
D(AVE)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
D(MIN)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AB(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AC(10)										
AD(10)										
AE(10)										
AF(10)										
AG(10)										
AH(10)										
AI(10)										
AJ(10)										
AK(10)										
AL(10)										
AM(10)										
AN(10)										
AO(10)										
AP(10)										
BC(10)										
BD(10)										
BE(10)										
BF(10)										
BG(10)										
BH(10)										
BI(10)										
BJ(10)										
BK(10)										
BL(10)										
BM(10)										
BN(10)										
BO(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Figure 8.4.4.3-2 Interclass Divergence Table (1 through 10)

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MINIMUM=XXX			INTERCLASS DIVERGENCE TABLE WITH RANKING BASED ON D(AVE) BEST SPECTRAL BAND SETS							MAXIMUM=XXX
	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
D(AVE)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
D(MIN)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AB(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AC(10)										
AD(10)										
AE(10)										
AF(10)										
AG(10)										
AH(10)										
AI(10)										
AJ(10)										
AK(10)										
AL(10)										
AM(10)										
AN(10)										
AO(10)										
AP(10)										
BC(10)										
BD(10)										
BE(10)										
BF(10)										
BG(10)										
BH(10)										
BI(10)										
BJ(10)										
BK(10)										
BL(10)										
BM(10)										
BN(10)										
BO(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Figure 8.4.4.3-3 Interclass Divergence Table (11 through 20)

MINIMUM=XXX

INTERCLASS DIVERGENCE TABLE
WITH RANKING BASED ON D(AVE)
BEST SPECTRAL BAND SETS

MAXIMUM=XXX

	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
D(AVE)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
D(MIN)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AB(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AC(10)										
AD(10)										
AE(10)										
AF(10)										
AG(10)										
AH(10)										
AI(10)										
AJ(10)										
AK(10)										
AL(10)										
AM(10)										
AN(10)										
AO(10)										
AP(10)										
BC(10)										
BD(10)										
BE(10)										
BF(10)										
BG(10)										
BH(10)										
BI(10)										
BJ(10)										
BK(10)										
BL(10)										
BM(10)										
BN(10)										
BO(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Figure 8.4.4.3-4 Interclass Divergence Table (21 through 30)

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8.4.4.3.2 Feature Selection Displays

The feature selection reports resulting from the without replacement Bhattacharyya distance computations are illustrated in Figures 8.4.4.3-5 through 8.4.4.3-9. The first page of the Feature Selection report contains user input data and seperability information. The following pages contain more detailed data for intraclass, interclass, widely seperated subclass pairs, and other separabilities.

8.4.4.4 Classification Summary Display

The classification summary display will contain data relating to the performance of the classification processor. The display first page (Figure 8.4.4.4-1) will identify the image from which the data was generated followed by a list of category/class/subclass names that were considered during classification (the symbol will be listed also) and the corresponding percent threshold values and a priori constants. The channels used to perform the classification will be the final column on the first page.

Then, on the second and following pages will be a list of individual training and test fields with their classification summary results. Groups of training fields for a subclass will be totaled as well as groups of test fields. Columns of data on these pages will list (as shown in Figure 8.4.4.4-2) the field ID, the subclass name, number of samples in the field, percent correct classification (number of samples classified into the category assigned to the field divided by the number of samples in the field times one hundred), and the number of samples classified into each category/class/subclass. A page capability will exist to observe all categories/classes/subclasses and all fields.

The category/class/subclass names will be listed left to right; i.e., the category name will be listed followed by the first class in the category and then the subclasses within that class. Then the second class in the category will be listed followed by the subclasses in the second class and so on until that category's subdivisions are exhausted. The second category will be listed next, organized in the same order as above. This sequence will be continued until all categories are exhausted.

Alternatively, if the mensuration option had been selected on the Classification Summary Report Menu, the 'numbers of samples' values throughout the display shall be replaced by area measurements reflecting the parameters input on the Mensuration Report Menu. The display shall also indicate the units and scaling from the Mensuration Menu.

8.4.4.5 Bhattacharyya Chaining Reports.

Two chaining reports will be generated when the chaining report option is selected. The first report displays the initial Bhattacharyya distances between all subclass pairs involved in the chaining (See Figure 8.4.4.5-1.) The second report reflects the distances between the resultant chains. (See Figure 8.4.4.5-2.)

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FEATURE SELECTION REPORT

OPTION EXERCISED: WITHOUT REPLACEMENT - SEEKING X.XXX RATIO | TOTAL SEPARABILITY

BEST CHANNEL SUBSET
XX XX XX | X.XXXXXXXX

CHANNELS UNDER CONSIDERATION
XX XX XX XX XX XX XX XX XX XX XX XX | X.XXXXXXXX

CHANNELS AVAILABLE ON IMAGE
XX XX XX XX XX XX XX XX XX XX XX XX | RATIO

X.XXXXX

CATEGORY APRIORI ENVIRONMENT

CATEGORY	APRIORI	CATEGORY	APRIORI	CATEGORY	APRIORI
X	XX	X	XX	X	XX
X	XX	X	XX	X	XX

Figure 8.4.4.3-5 Feature Selection Report Menu

INTRACLASS SEPARABILITIES

CLASS	NUMBER OF SUBCLASSES	FULL SET OF CHANNELS	SELECTED BEST SUBSET	RATIO
XXXX	XX	X.XXXXXXX	X.XXXXXXX	X.XXXXXXX
XXXX	XX	X.XXXXXXX	X.XXXXXXX	X.XXXXXXX

Figure 8.4.4.3-6 Intraclass Separabilities Menu - Class

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INTERCLASS SEPARABILITIES

CLASS PAIRS	FULL SET OF CHANNELS	SELECTED BEST SUBSET	RATIO
XXXX/XXXX	X.XXXXXXX	X.XXXXXXX	X.XXXXXXX
XXXX/XXXX	X.XXXXXXX	X.XXXXXXX	X.XXXXXXX

Figure 8.4.4.3-7 Interclass Separabilities Menu - Class Pairs

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OTHER SEPARABILITIES

CATEGORY OTHER IS S WITH APRIORI VALUE OF XX AND XX SUBCLASSES

CLASS	FULL SET OF CHANNELS	SELECTED BEST SUBSET	RATIO
XXXX	X.XXXXXXX	X.XXXXXXX	X.XXXXXXX
XXXX	X.XXXXXXX	X.XXXXXXX	X.XXXXXXX

Figure 8.4.4.3-8 Other Separabilities

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WIDELY SEPARATED SUBCLASS PAIRS

BHATTACHARYYA DISTANCE THRESHOLD X.XXXXXX

SUBCLASS PAIR	BHATTACHARYYA DISTANCE	SUBCLASS PAIR	BHATTACHARYYA DISTANCE
XXXXXX/XXXXXX	.XXXXXXXX	XXXXXX/XXXXXX	.XXXXXXXX
XXXXXX/XXXXXX	.XXXXXXXX	XXXXXX/XXXXXX	.XXXXXXXX

Figure 8.4.4.3-9 Widely Separated Subclass Pairs

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DETAILED CLASSIFICATION SUMMARY

IMAGE=XXXXXXXXXXXX
MENSURATION SCALING=XXX.XXXX ACRES/PIXEL

CATEGORY	SUBCLASS	PERCENT	A PRIORI	CATEGORY	SUBCLASS	PERCENT	A PRIORI	CHANNELS CONSIDERED
X	XXXXXX	XXX.X	XXX	X	XXXXXX	XXX.X	XXX	XX
								XX
X	XXXXXX	XXX.X	XXX	X	XXXXXX	XXX.X	XXX	

Figure 8.4.4.4-1 Detailed Classification Summary

CLASSIFICATION SUMMARY REPORT

FIELD/ SCLASS	NUM. OF SAMPLES	PCT CORR	X	THRS	XXXX	THRS	XXXXXX	THRS	X	THRS
XXXXXXX XXXXXXX	XXXXXX	XXX.X	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
TRNG XXXXXX										
XXXXXXX XXXXXX										
TRNG XXXXXX										
XXXXXXX XXXXXX										
TRNG XXXXXX										
XXXXXXX XXXXXX										
TRNG XXXXXX										
XXXXXXX XXXXXX										
TEST XXXXXX	XXXXXX	XXX.X	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX

Figure 8.4.4.4-2 Classification Summary Report Menu

Approved: ______ NASA/DPB ______ PHO

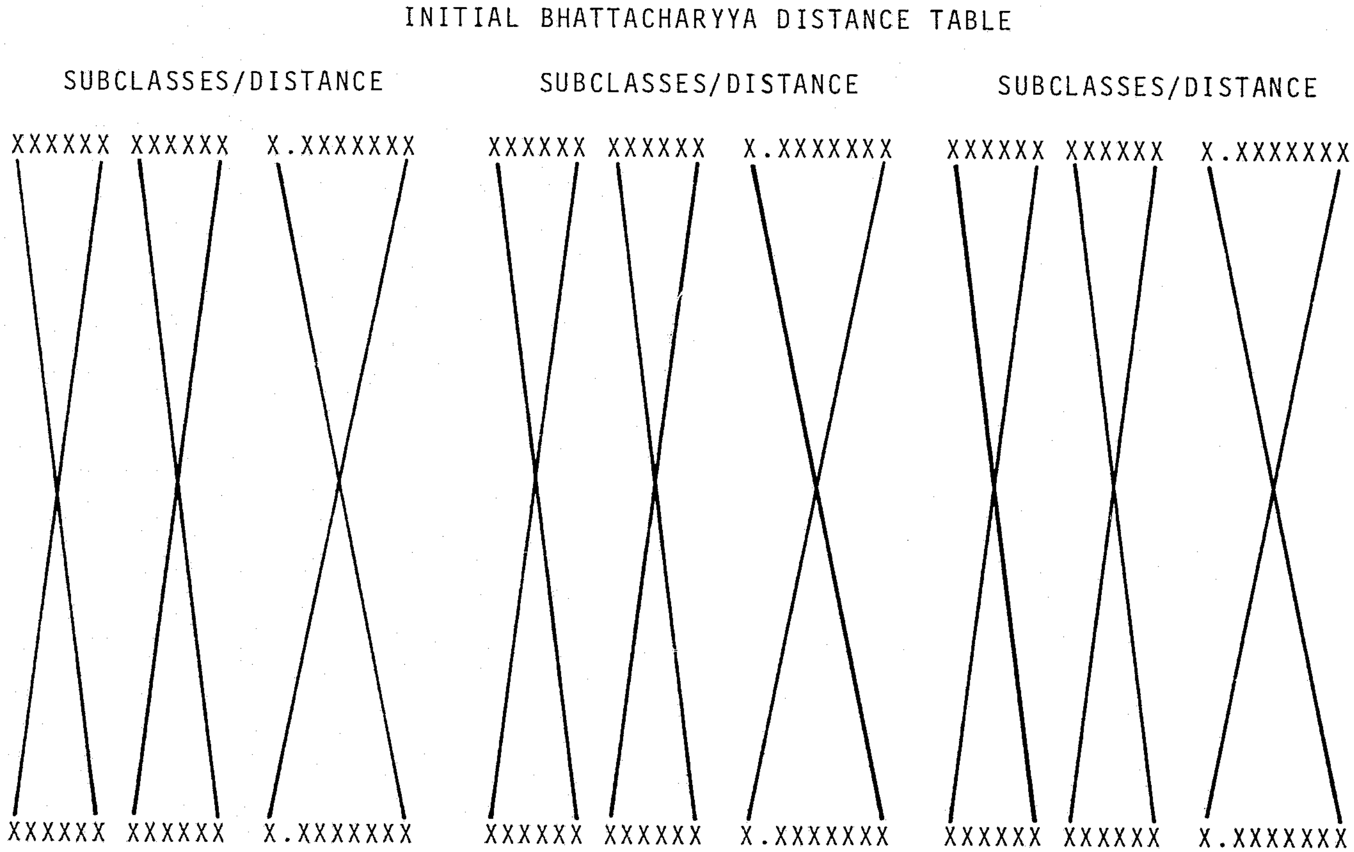

Figure 8.4.4.5-1 Initial Bhattacharyya Distance Table

FINAL BHATTACHARYYA DISTANCE TABLE

CHAINS/DISTANCE	CHAINS/DISTANCE	CHAINS/DISTANCE	CHAINS/DISTANCE
XX XX X.XXXXXXX	XX XX X.XXXXXXX	XX XX X.XXXXXXX	XX XX X.XXXXXXX
XX XX X.XXXXXXX	XX XX X.XXXXXXX	XX XX X.XXXXXXX	XX XX X.XXXXXXX

Figure 8.4.4.5-2 Final Bhattacharyya Distance Table

Approved: [signature] NASA/DPB PHO

8.4.4.6 Image Merge Report.

The Image Merge Report (Figure 8.4.4.6-1) lists the sample segment numbers and acquisition dates of the merged composed image data set being analyzed.

8.4.4.7 Crop Assessment Subsystem Interface Tape

When operating in the LACIE batch mode, a Crop Assessment Subsystem (CAS) interface tape will be output for use by an offline program designed to aggregate crop production and assess system accuracies. The following paragraph is presented to aid in the design of the processor.

The tape used shall be an ASCII format labeled tape containing one data file and an end-of-file signaled by three consecutive end-of-file marks. The data file consists of multiple data sets with each set being one or more physical records. Each record shall have an identifier in the first byte indicating that this record contains recognition segment data or fields data and a sequence value in the second byte. When both recognition segment data and fields data is to be written on tape, recognition segment data will always precede fields data.

A. Recognition Segment Data. The recognition data content on the CAS interface tape shall be as follows:

1. Record Identification
2. Record Sequence Number
3. DPAR Number
4. Run ID
5. BHATTACHARYY Separability (All channels)
6. External Statistics Tape Number
7. Number of Recognition Segment Subclasses
8. Number of Merged Image Fields
9. Number of Pixels in D/O Fields
10. Number of Pixels in D/U Fields
11. Date of Classification
12. Number of Acquisitions used for Classifications

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IMAGE MERGE CHANNEL CORRESPONDANCE REPORT

DATA FROM SITE	ACQUISITION DATE USED TO FORM CHANNELS 1-4	5-8	9-12	13-16
XXXX	XXXXX	XXXXX	XXXXX	XXXXX
XXXX	XXXXX	XXXXX	XXXXX	XXXXX

OUTPUT IMAGE WAS NAMED XXXXXXXXXXXXXX

Figure 8.4.4.6-1 Image Merge Report

13. Channels used in Classifications

14. BHATTCHARYYA Separability (Channels used for Classification)

15. Biological Windows 1 thru 4

    (a) Window 1

    - Beginning Day - Year
    - Ending Day - Year

    (b) Window 2

    - Beginning Day - Year
    - Ending Day - Year

    (c) Window 3

    - Beginning Day - Year
    - Ending Day - Year

    (d) Window 4

    - Beginning Day - Year
    - Ending Day - Year

16. Segment Related Information

    (a) Sample Segment Data

    (1) Segment Number

    (2) Spring/Winter Wheat

    (3) Sample Segment Use Indicator

    (b) Channel Set Acquisition Dates

    (1) Channel Set 1

    (2) Channel Set 2

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(3) Channel Set 3

(4) Channel Set 4

(c) Training Segment Data

(1) Segment Numbers

(2) Spring/Winter Wheat Indicators

(d) Channel Sets Acquisition Dates

(1) Channel Set 1

(2) Channel Set 2

(3) Channel Set 3

(4) Channel Set 4

17. Threshold and A Priori values by Category

(a) Category Name

(b) Classification Level Indicator

(c) Threshold Value

(d) A Priori Value (Normalized)

18. Subclass Classification Results for All Subclasses

(a) Subclass Name

(b) Statistics Manipulation Flags

(c) Pixels Classified Into Subclass

(d) Pixels Thresholded Out of Sublcass

B. Fields Data. The fields data content on the CAS interface tape shall be as follows:

1. Record Identifier

2. Record Sequence Number

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3. Field Name

4. Subclass

5. Field Type

6. Field Population (Total Number of Pixels)

7. Number of Subclasses

8. Classifi_ation results by Subclass

(a) Subclass Name

(b) Mean Level Adjusted Flag

(c) Sun Angle Corrected Flag

(d) Pixels classified into Subclasses

(e) Pixels thresholded out of Subclasses.

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Where:

II = 2
N = Number of channels

DEFAULT2

Same as DEFAULT1 except set Maximum number of clusters 20, ITMAX 8

9.2.2.2 Clustering Summary Report Menu (Figure 9.2.2.2-1)

A. The Clustering Report Menu will display the following:

1. A run number indication.

2. A list of each cluster, for the current run, showing:

- Cluster number
- Population
- CLASS MATCH - Name of class in statistics table which most closely matches each cluster.
- DISTANCE - RMS difference in means between each cluster and the closest class match.
- CLUSTER MATCH - Name of cluster in statistics table which most closely matches each cluster.
- DISTANCE - RMS difference in means between each cluster and the closest cluster match.

B. The Clustering Report Menu will require user input of the following:

1. NAME - An entry of the cluster name.

2. CANCEL - An option to cancel a cluster(s) by entering letter C, or to specify a cluster for GOODNESS of FIT (Paragraph 8.2.11) by entering G.

3. DETAILED REPORT - An option to generate a detailed clustering report (refer to Paragraph 9.4.4.1, Figure 9.4.4.1-1).

4. DISTANCE TABLE - An option to generate an intercluster distance table (refer to Paragraph 9.4.4.2, Figure 9.4.4.2-1).

5. CHAINING - An option to request chaining (refer to Paragraph 9.2.2.3).

Approved: TGP NASA/DPB RNL PHO

Approved: ______ NASA/DPB ______ PHO

MEAN AND STANDARD DEVIATION REPORT MENU

PLEASE SELECT THE DESIRED REPORT

CLASS REPORT [ ]

FIELD REPORT [ ]

BOTH REPORTS [ ]

IMD

SCR

RET

EOF

EOT

Figure 8.2.10.4-1 Mean-Standard Deviation Report Menu

IMD

SCR

DIVERGENCE REPORT MENU

PLEASE SELECT ORDERING OPTION

RANKING WITH RESPECT TO D(AVE) ☐

RANKING WITH RESPECT TO D(MIN) ☐

RANKING WITH RESPECT TO USER (I,J,) PAIR ☐

RET

EOF

EOT

Figure 8.2.10.5-1 Divergence Report Menu

Approved: ____________ NASA/DPB ____________ PHO

B-distance Separability Report

To be determined

Figure 8.2.10.6-1

Approved: ______________________ NASA/DPB ______________________ PHO

B-matrix Summary Report

To be determined

Figure 8.2.10.7-1

Approved: ______________ NASA/DPB ______________ PHO

CLASSIFICATION SUMMARY MENU

IMD

SCR

PLEASE ENTER THRESHOLD VALUES

☐ SPECIFY MENSURATION, IF DESIRED

ALL CLASSES __.__%

OR VALUE FOR EACH CLASS

CLASS	VALUE	CLASS	VALUE	CLASS	VALUE	CLASS	VALUE
XXXXXX	__.__%	XXXXXX	__.__%	XXXXXX	__.__%	XXXXXX	__.__%
XXXXXX	__.__%	XXXXXX	__.__%	XXXXXX	__.__%	XXXXXX	__.__%

RET

EOF

EOT

Figure 8.2.10.8-1 Classification Summary Menu

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PHO-TR514
Change 5
11 March 1975

MENSURATION SCALING MENU

[IMD]

[SCR]

SELECT THE APPROPRIATE UNITS FOR AREA MEASUREMENT:

☐ ACRES

☐ HECTARES

☐ SQUARE KILOMETERS

EOF

ENTER THE SCALE FACTOR (UNITS/PIXEL) TO BE USED IN AREA MEASUREMENT:

EOT

[RET]

☐ WRITE MENSURATION RESULTS TO TAPE

[EOF]

[EOT]

Figure 8.2.10.9-1 Mensuration Scaling Menu

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8.2.12 Signature Extension Processor

8.2.12.1 Signature Extension Menu

The Signature Extension (figure 8.2.12.1-1) allows the user to checkpoint all data, writing data to tape, by only cursoring the CHECKPOINT box. To checkpoint class statistics only or fields only, the user may cursor the CHECKPOINT and CLASS STATS ONLY boxes or CHECKPOINT and FIELDS ONLY boxes, respectively. By cursoring the CHECKPOINT box, the data will include fields and statistics (field and class), and, if divergence has been executed, the best channel sets for D(AVE), D(MIN), and D(I, J) options will be included. The user may restart his run later by cursoring the SIGNATURE EXTENSION box and typing the tape number of the tape containing his Signature Extension data. Refer to Paragraph 8.3.6 for the data checks.

LACIE use of this application will involve both reading field definitions and specific class information from the fields data base and writing the same data to tape to allow for a data base update capability. This will be done by typing in up to four segment numbers and cursoring the appropriate immediate action box; i.e., FD to read the fields data or TU for a tape unload of fields data.

When reading from the fields data base, it will be necessary to add information to both the field and class names and to update line numbers for the field vertices in order to keep track of fields and classes belonging to different segments of the merged image. Then, when writing data base update information to tape, the reverse process must be performed. An additional problem arises, in that the interactive user may define fields across the segment boundaries; i.e., across the line values 117, 214 or 331. The program will check for this condition and not write these field definitions to tape. Also, the user will be informed of the situation. Field name, class name, and field definitions will be modified as follows:

- Field names. A digit 0, 1, 2 or 3 will be added to the field name to designate whether the field belongs to the recognition segment, training segment 1, training segment 2, or training segment 3, respectively.

- Class Names. Again, a digit 0, 1, 2 or 3 will be added, but for class names to the second character of the name. Designation of the digit is as for field names.

- Field Definitions. Since the recognition segment and the training segments are merged vertically, the line numbers within the merged image are renumbered to reflect the new total size of the image and, therefore, necessitates a change in the field vertex information when the fields are read from the data base. Vertex line numbers will be updated by adding 117n to the actual line number where n is the training segment digit, 1, 2, or 3.

8.2.12.2 Signature Extension Data Display

The Signature Extension Data Display, figure 8.2.12.2-1, will be displayed, if the user has cursored the SIGNATURE EXTENSION box and typed a Signature Extension tape number. This report will allow the user to verify the contents of the Signature Extension tape. The user may continue by cursoring the CON box or cancel by cursoring the RET box.

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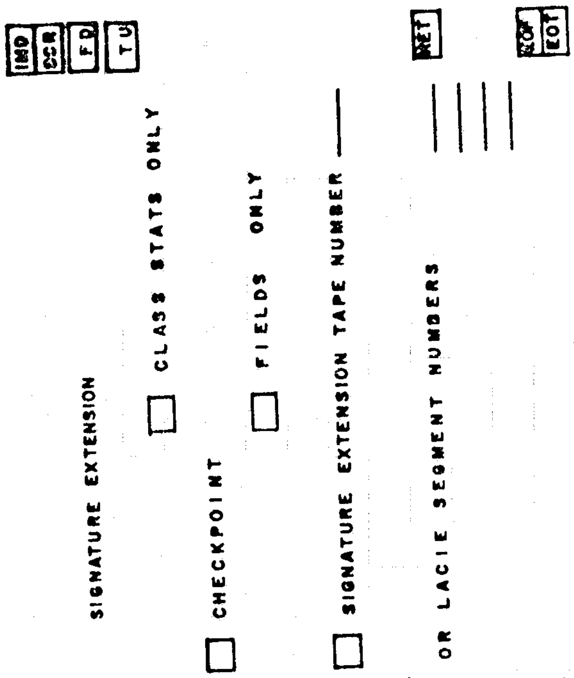

Figure 8.2.12.1-1 Signature Extension Menu

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SIGNATURE EXTENSION DATA DISPLAY

IMO

SCR

CON

USER NAME XXXXXXXXXXXX

DATE XXXXXX TIME XXXX

TAPE NUMBER XXXXXX

TERMINAL ID X RUN NUMBER X

IMAGE NAME XXXXXXXXXXXX

NUMBER OF CHANNELS XX

FIRST LINE XXXXX

FIRST PIXEL XXXX

NUMBER OF LINES XXXXX

NUMBER OF PIXELS XXXX

LINESKIP X

PIXELSKIP X

CHANNEL NUMBERS

XX XX XX

XX XX XX

DIVERGENCE THREE BEST SETS

D(AVE) D(MIN) D(I,J)

XX XX XX

XX XX XX

RET

CHECK SPECIAL ACTION BOX CON TO CONTINUE RESTART PROCESSING

OTHERWISE CHECK SPECIAL ACTION BOX RET

EOF

EOT

Figure 8.2.12.2-1 Signature Extension Data Display

8.2.13 Goodness of Fit Processor

8.2.13.1 Goodness of Fit Selection

The Goodness of Fit Processor may be selected from the Pattern Recognition processor selection menu (Figure 8.2.2.2-1), or from the Clustering Summary Report Menu (Figure 9.2.2.2-1). If the user selects the Goodness of Fit Processor from the Clustering Summary Report Menu, he must have entered G in the cancel column of that report to specify the cluster that he wishes to test for goodness of fit.

8.2.13.2 Goodness of Fit Tests Menu

When the user selects the goodness of fit processor, the menu shown in Figure 8.2.13.2-1 is displayed. This menu requests inputs of class or field name (not applicable if selected from the Clustering Summary Report), the channels to which the tests are to be applied and specification of either the Pearson Chi-Square Test on the Kolmogorov-Smirnov Test. If the Pearson Chi-Square Test is selected, then the user must define either the desired number of intervals with options of equally populated intervals, or a user specified number of intervals.

The report portion of the menu will be used to return a goodness of fit value and a percentile computed from the user specified test option.

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GOODNESS OF FIT TESTS

CLASS OR FIELD XXXXXXX (DISREGARD IF CLUSTER)

CHANNELS [ALL]

[1] [2] [3] [4] [5] [6]

[7] [8] [9] [10] [11] [12]

[13] [14] [15] [16] [17] [18]

[19] [20] [21] [22] [23] [24]

[25] [26] [27] [28] [29] [30]

[ ] PEARSON CHI-SQUARE TEST   VALUE XXXX
                               PERCENTILE XXX   [RET]

[ ] NUMBER OF INTERVALS

    [ ] EQUALLY POPULATED INTERVALS

[ ] KOLMOGOROV-SMIRNOV TEST   VALUE XXXX
                               PERCENTILE XXX

[EOF]

[EOT]

Figure 8.2.13.2-1 Goodness of Fit Tests Menu

8.3 PROCESSING REQUIREMENTS

8.3.1 Statistics Processor

The training fields (paragraph 8.2.3) will be the operating data base for the statistics processor which will provide:

- histograms of radiance distributions of user-selected fields and/or classes in specified channels,
- field and class means in each channel, and all covariance matrix elements.

The histograms will be employed as analysis aids. The field and class means, and covariance matrix elements will be used as input data to other pattern recognition sub-processors at user discretion.

Representations of field means and covariance matrix element expressions have been selected to expedite processing efficiency. The class statistics expressions, derived from MSC Internal Note 72-FM-154, 5 July 1972, treat classes explicitly as the union of their training fields and permit ready addition or deletion of training fields without recomputing the complete class statistics.

8.3.1.1 Histograms

Training field definitions and the image data set will be used to display histograms of user-designated fields (and/or classes) in a specified channel. These displays shall indicate the percentage of elements in the region for each radiance level represented in the field (or class) and channel. The histogram, therefore, is the discrete distribution function of the channel data.

The capability shall exist to display one, two, or three fields and/or classes of histogram data simultaneously in a single channel. Requests for more than three histograms in a channel shall be accepted; the data is to be retrieved for additional fields by paging the histgram report. Histograms for more than one channel shall be requested separately.

8.3.1.2 Field Statistics

A. Field Means

For a channel i and training field f:

$$\mu_i^f = \frac{1}{N_f} \sum_{k=1}^{N_f} X_{ki}^f \qquad (1)$$

where: μ_i^f = mean of channel i data in f.

X_{ki}^f = k^{th} channel i element (pixel) value in f.

N_f = number of elements in f.

Means are computed for each i in the image data set.

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B. Field Covariance Matrix Elements

An element of the covariance matrix for field f represents the covariance between a pair (i,j) of channel data taken over all elements of f. These elements shall be computed:

$$\Gamma_{ij}^{f} = \frac{1}{N_f} \sum_{k=1}^{N_f} \left(X_{ki}^{f} \, X_{kj}^{f} \right) - \mu_i^f \mu_j^f \tag{2}$$

where:

μ_i^f = mean of channel i data in f

μ_j^f = mean of channel j data in f

N_f = number of elements in f

X_{ki}^f = kth channel i element (pixel) value in f

X_{kj}^f = kth channel j element (pixel) value in f

Γ_{ij}^f = the (i,j) covariance matrix element in f.

NOTE.

Since $\Gamma_{ij}^f = \Gamma_{ji}^f$, computations are to be performed only for $i \leq j$, to minimize processing.

C. Standard Deviations

The standard deviation, σ_i^f, of channel i in f is given by:

$$\sigma_i^f = \left(\Gamma_{ii}^f \right)^{1/2}$$

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D. Correlation Matrix

The correlation (normalized covariance) matrix element is to be computed for each covariance element for all fields:

$$\gamma_{ij}^{f} = \Gamma_{ij}^{f} / (\sigma_i^f \sigma_j^f)$$

with $i \leq j$ as in (B).

NOTE

$\gamma_{ii}^{f} = 1$ for all i.

8.3.1.3 Class Statistics

The following expressions for class means and covariance matrix elements are based on a treatment of fields as partitions of the class under investigation. These expressions are iterative over the fields defined for the class, and permit extraction or incorporation of fields in a straightforward manner.

A. Class Means

1. addition of a field to a class

$$\mu_i^{[k]} = \frac{N_{[k]} - N_k}{N_{[k]}} \mu_i^{[k-1]} + \frac{N_k}{N_{[k]}} \mu_i^{k} \qquad (3)$$

where:

$\mu_i^{[k]}$ = mean of channel i data over the first k fields in the class.

μ_i^{k} = mean of the k^{th} field in channel i, as obtained in paragraph 8.3.1.2 A, equation (1)

$N_{[k]}$ = total number of elements in fields 1, . . ., k.

N_k = number of elements in field k.

2. deletion of fields from a class

The user shall have the capability to eliminate a specified training field from the class statistics. The following equation, subtractive form of equation (3), shall provide that capability:

$$\mu_i^{[k-1]} = \frac{N_{[k]}}{N_{[k]} - N_k} \left[\mu_i^{[k]} - \frac{N_k}{N_{[k]}} \mu_i^{k} \right]$$

(The k^{th} field is thereby removed from the class.)

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μ_i^k = mean of the k^{th} field in channel i, as obtained in paragraph 8.3.1.2 A, equation (1)

$N_{[k]}$ = total number of elements in fields 1, . . ., k.

N_k = number of elements in field k.

B. Class Covariance Matrix Elements

1. addition of a field to a class

An element, $\Gamma_{ij}^{[k]}$, of the class covariance matrix (for the first k fields of the class) will be computed from the [k-1] term by:

$$\Gamma_{ij}^{[k]} = \frac{1}{N_{[k]}-1}\Big[\left(N_{[k]}-N_k-1\right)\Gamma_{ij}^{[k-1]} + \left(N_k-1\right)\Gamma_{ij}^{k} + N_k\left(\mu_i^{[k]}-\mu_i^k\right)\left(\mu_j^{[k]}-\mu_j^k\right) + \left(N_{[k]}-N_k\right)\left(\mu_i^{[k]}-\mu_i^{[k-1]}\right)\left(\mu_j^{[k]}-\mu_j^{[k-1]}\right)\Big]$$

in which each Γ_{ij}^k is obtained through equation (3).

2. deletion of a field from a class.

The subtractive form* of the equation above is to be used to establish the covariance matrix elements of the class following the deletion of a field k:

$$\Gamma_{ij}^{[k-1]} = \frac{N_{[k]}}{N_{[k]}-N_k}\Big[\Gamma_{ij}^{[k]} - \frac{N_k}{N_{[k]}}\Gamma_{ij}^{k} - \frac{N_k}{N_{[k]}}\left(\mu_i^{[k]}-\mu_i^k\right)\left(\mu_j^{[k]}-\mu_j^k\right) - \frac{N_{[k]}-N_k}{N_{[k]}}\left(\mu_i^{[k]}-\mu_i^{[k-1]}\right)\left(\mu_j^{[k]}-\mu_j^{[k-1]}\right)\Big]$$

*Using the biased estimator of MSC Internal Note 72-FM-154.

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C. Standard Deviations

The standard deviation , σ_i^c, of channel i in class C is given by:

$$\sigma_i^c = \left(\Gamma_{ii}^c\right)^{1/2}$$

D. Correlation Matrix

The correlation matrix elements for the class C are to be computed:

$$\gamma_{ij}^c = \Gamma_{ij}^c / \left(\sigma_i^c \sigma_j^c\right),$$

with $i \leq j$ as in (8.3.1.2 B), $\gamma_{ii}^c \equiv 1$ for all i.

8.3.1.4 Statistics Manipulation

Statistics manipulation for sun angle correction and mean-level adjustment will be selected by the user as an operation to be performed on the class statistics generated in any of the user specified statistics options. These manipulations are performed to enhance the capability of extending signatures from one area that contains ground truth information to another area that does not. References in this section will be made to "reference" and "object" parameters with the "reference" pertaining to the non-groundtruth area and the "object" to the groundtruth area. That is, when the "reference" sun angle is discussed, the sun angle that is being refered to is the sun angle of the area to which signatures are to be extended. The final statistics manipulation is to be performed automatically. Class covariance matrices will be checked for singularity and if necessary will be manipulated as shown below.

8.3.1.4.1 Sun Angle Correction

Sun angle correction will provide the user a means for normalizing data between areas that have different sun angle elevations. A table of coefficients (a_j, β_i) versus the sun angles of the reference and object areas will be provided. There will be two coefficients, a_i and β_i for each channel with a specific sun angle, i.e., an N channel image would have 2N coefficients. The sun angle ranges of the table will be 20° to 70° in increments of 1°. The coefficient a_i will have a decimal value X.XXX varying between 0 and 5.000 and β_i a decimal value XX.XX varying between -100 and 100. After the coefficient values have been determined, the class statistics will be corrected as follows:

$$\mu_i^{c'} = a_i \cdot \mu_i^c + \beta_i \qquad (1)$$

where:

$\mu_i^{c'}$ = the corrected mean in channel of the C^{th} class

a_i = 1st correction coefficient for channel i corresponding to ζ_r and ζ_o

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ζ_r, ζ_o = sun angles of the reference (r) and object (0) images

μ_i^c = mean in ch nnel i of the C^{th} class

β_i = 2nd correction coefficient for channel i corresponding to ζ_r and ζ_o

The class covariance is then:

$$\Gamma_{ij}^{c'} = \Gamma_{ij}^{c} \alpha_i \alpha_j \tag{2}$$

where:

Γ_{ij}^{c} = the element of the covariance matrix for the C^{th} class representing the relationship between a pair (i,j) of channel data

$\Gamma_{ij}^{c'}$ = the corrected Γ_{ij}^{c}

α_i = correction coefficient for channel i corresponding to ζ_r and ζ_o

α_j = As α_i but for channel j

8.3.1.4.2 Mean Level Adjustment

The means are to be computed in the reference area and in the object area for the mean-level adjustment fields. If sun angle correction was performed, the means will be corrected as in the Paragraph 8.3.1.4.1. Then mean-level adjustment will be done as follows:

$$\Delta\mu_i = \mu_i^o - \mu_i^r \tag{3}$$

where:

μ_i^o = mean over the MLA fields in the object area for channel i

μ_i^r = as μ_i^o but for ref..ence area

The mean will then be adjusted for each class statistic as:

$$\mu_i^c = \mu_i^c - \Delta\mu_i$$

where:

μ_i^c, μ_i^c and $\Delta\mu_i$ are as before.

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8.3.1.4.3 Covariance Singularity Adjustment

During further processing the generated class covariance matrices must be inverted. If because of singularity conditions a matrix cannot be inverted, the matrix will be modified according to the following rule:

$$\Gamma_{ij}^{c'} = \Gamma_{ij}^{c} + EI \tag{4}$$

where:

Γ_{ij}^{c} = class covariance matrix to be modified

E = a constant value 0.1

I = the identity matrix

$\Gamma_{ij}^{c'}$ = the modified class covariance matrix

This modification will be repeated a maximum of five times. The user will be notified of the number of modifications required. Also, if five attempts do not correct the singularity, the job will be aborted and the user notified.

8.3.1.5 Bhattacharyya Chaining Processor

The Bhattacharyya distance (B-distance) function is discussed in Paragraph 8.3.2.2.1 as applied to the Feature Selection Processor and referenced in other sections of this document. The application of this distance function in this case is to chain fields of the same class that contain a number of subclasses. Therefore the chaining processor will chain subclasses of a class into a different group of subclasses as follows:

Intraclass B-distance

$$H[ij, ik] = \exp\left[-\frac{1}{4}\delta_{jk}^{T}\left(\Gamma_{ij} + \Gamma_{ik}\right)^{-1}\delta_{jk} - \frac{1}{2}\ln\left(\frac{\left|\Gamma_{ij} + \Gamma_{ik}\right|}{2^{n}\left|\Gamma_{ij}\right|^{1/2}\left|\Gamma_{ik}\right|^{1/2}}\right)\right]$$

where:

i = class identifier

j, k = subclass identifiers

$\delta_{jk} = \mu_{ij} - \mu_{ik}$, subclass means

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Γ_{ij}, Γ_{ik} = subclass covariance matrices

$| \ |$ = determinant function

n = number of channels

then if, $H[ij, ik] > 0.5$, combine the statistics of the two fields/subclasses into one field/subclass.

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8.3.2 Feature Selection Processors

The objective of the feature selection applications is the reduction of the channel dimensionality of an image from N to k<N. The k coordinates represent either a proper subset or linear combinations of the original channel set. The function performed in any of these processors is the elimination from consideration of those channels in which little or no definition between the defined classes can be made.

Two separability measures and three channel search procedures are to be provided in accordance with the controls identified in Paragraph 8.2.7 and with the requirements below.

8.3.2.1 Divergence Processor (Exhaustive Search)

The divergence processor will provide a user capability to select a "best" channel set to be used in the classification process. The divergence process involves the use of a methodology to measure the degree of statistical separability of the probability distributions of each of the classes. The output results (output format is described in paragraph 8.4.4.4) is a list of the "best" sets of channels to be utilized in the classification of the data into the classes chosen, minimizing the probability of misclassification.

8.3.2.1.1 Inputs To The Divergence Processor

The following are inputs needed to compute the best set of channels (spectral bands) to be used for maximum separability (divergence).

A. Channels. The channels not to be considered in selecting the optimum set of channels for maximum spearability. The default will be all channels. The maximum number of channels to be considered will not exceed 30.

B. Channel Set Size. The number of channels in a selected set. Maximum channel set size will be eight. The default will be four channels.

C. Classes. The classes for which optimum separability is to be determined. These must be input. Each class will have been given a character name and a character symbol.

D. Weighting Factors. Weight to be applied to a particular pair of classes in determining average divergence. This will be a value from 0-10 (10 is the default).

E. D(MAX) Maximum value of pairwise divergence. If a computed weighted pairwise divergence exceeds this value, the pairwise divergence is assigned the D(MAX) value. (Default is 999)

F. D(MIN) Minimum value of pairwise divergence. If a computed pairwise divergence falls below this value for a channel set, the set is not considered.

G. Ranking. Method to be used to rank the best channel sets; i.e., D(AVE), D(MIN) or user specified class pair, D(I,J)

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8.3.2.1.2 Divergence Processor Computations

8.3.2.1.2.1 Divergence

The divergence between the C^{th} and K^{th} classes given a set of up to 30 channels is defined as:

$$D_{ck} = \sum_{i=1}^{N}\sum_{j=1}^{N}\left(\Gamma_{ij}^{c} - \Gamma_{ij}^{k}\right)\cdot\left(\Gamma_{ij}^{-k} - \Gamma_{ij}^{-c}\right) + \sum_{i=1}^{N}\sum_{j=1}^{N}\left(\Gamma_{ij}^{-k} + \Gamma_{ij}^{-c}\right)\cdot \Delta_i \Delta_j$$

where:

N = channel set size (maximum 8, default 4)

Γ_{ij}^{c} = the element of the covariance matrix for the C^{th} class representing the relationship between a pair (i,j) of channel data.

Γ^{c} = covariance matrix for class C

$\Gamma_{i,j}^{-c}$ = the (i,j) element of the matrix inverse of Γ^{c}

$\Delta_i = \mu_i^{c} - \mu_i^{k}$.

μ_i^{c} = mean in channel i of class C

8.3.2.1.2.2 Transformed Divergence

The transformed divergence between the C^{th} and K^{th} classes will then be computed from the divergence, D_{ck}, as:

$$T_{ck} = 999\ [1 - \exp(-D_{ck} / 16)]$$

8.3.2.1.2.3 Weighted Divergence

Then the weighted divergence between the C^{th} and K^{th} classes will be computed from the transformed divergence, T_{ck}, as:

$$W_{ck} = W \cdot T_{ck}/10.0$$

where:

W = the user designated weight for the class pair, (c,k)

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8.3.2.1.2.4 Average Divergence

The average divergence will be computed as the average of all weighted class-pair divergences, $W_{c\,k}$, for a particular channel set N.

$$D(AVE)_{c,k} = \frac{2}{M(M-1)} \sum_{i=1}^{M-1} \sum_{j=i+1}^{M} W_{c,k}$$

where:

M = the total number of considered classes

8.3.2.2 Bhattacharyya Distance Functions

The three optional uses of the B-distance measure are shown in Figure 8.2.7-1. All three require the computation of a total separability measure on all identified channels under several input controls:

A. Channels. The channels not to be considered in selecting the optimum set of channels for maximum separability. The maximum number of channels to be considered will not exceed 16.

B. Classes. The classes must be input for which optimum separability is to be determined.

C. Excluded Separability Class Set. A set of classes to be subject to no intraclass or interclass separability computation among themselves in the calculation of a total separability measure. These must be input.

D. A Priori Class Values. A set of input values indicating a bias to be made to each class weighting on the basis of prior information.

In the case of the Without Replacement and Iterator Options, the following two additional inputs may be made:

E. Separability Criterion. A value between 0 and 1 indicating the requirements on a channel subset separability in terms of a ratio between such a separability and an ALL CHANNELS total separability. This value is defaulted to 0.900.

F. Channel Set. A number of channels between 3 and 16 to be generated by the iterator as linear combinations of the original channel set. If defaulted, this value is determined on the basis of the smallest without replacement channel set satisfying the separability criterion of subparagraph E above.

8.3.2.2.1 B-Distance Separability

The distance measure employed is an exponential expression of the Bhattacharyya distance function, herein designated B-distance; the exponential form is such that, although monotonic, the function diminishes as the Euclidian distance measure increases.

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The structure of the equations below is predicated on the assumptions that the defined classes are of two types: a set of classes π_1 to π_X (see paragraph 8.2.7.4.1) with respect to which several measures of internal and mutual separability are of interest, and a set of classes π_{X+1} to π_Y (all other classes) for which distinction is not necessary or critical in the same sense as for the $\pi_1, ..., \pi_X$, and further that each class π_i (i=1, ..., y) may be composed of one or more subclasses π_{ij} (j=1, ..., j_i), for which class (subclass) statistics are defined.

The expressions below are to be calculated for each image entering the B-distance feature selection processors with a set of class statistics defined in the indicated manner. The same expressions are employed in subsequent paragraphs for channel subsets or linear combinations.

- B-distance:

$$H[ij,\ kl] = \exp\left[-\frac{1}{4}\delta_{jl}^{T}\left(\Gamma_{ij} + \Gamma_{kl}\right)^{-1}\delta_{jl} - \frac{1}{2}\ln\left(\frac{\left|\Gamma_{ij} + \Gamma_{kl}\right|}{2^{n}\left|\Gamma_{ij}\right|^{1/2}\left|\Gamma_{kl}\right|^{1/2}}\right)\right] \qquad (1)$$

where:

i, k are distinct classes (k,i may be equal)

j, l are subclass identifiers for i, k respectively

$\delta_{jl} = \mu_{ij} - \mu_{kl}$ as previously defined, an Nxl matrix

Γ_{ij}, Γ_{kl} are the covariance matrices for subclasses ij, kl

$|\Gamma_{ij}|$ is the determinant of Γ_{ij}

The B-distance is to be calculated over all channels N of the statistics under the following limits on i, j, k. l:

$i = 1, ..., Y$

$j = 1, ..., j_i$

$k = i, ..., Y$

$$\begin{cases} l = 1, ..., l_k \text{ when } i \neq k \\ l = j+1, ..., l_k \text{ when } i = k \end{cases}$$

- Distance flag

Subclasses having undesirable distance measures from other subclasses of the same class shall be flagged for output to report; this flag is established when:

$$H[ij,\ kl] < 0.5 \qquad (2)$$

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- Interclass separability

Compute between classes i and k ($i \neq k$):

$$\Psi(i, k) = \sum_{j=1}^{j_i} \sum_{l=1}^{l_k} \left(\rho_{ij} \quad \rho_{kl} \right)^{1/2} \quad H[ij, kl] \tag{3}$$

where $i = 1, \ldots, X$
$k = 1+i, \ldots, Y$

and ρ_{ij}, ρ_{kl} are the a priori probabilities determined or specified elsewhere (see Figure 8.2.7-9)

- Intraclass separability

Compute within each class $i = 1, \ldots, X$:

$$\Psi(ii) = \sum_{j=1}^{j_i - 1} \sum_{l=j+1}^{l_i} \left(\rho_{ij} \ \rho_{il} \right)^{1/2} \quad H[ij, kl] \tag{4}$$

where l_i designates here the subclasses of i.

- Intercategory separability

A separability measure is to be computed between each class π_i ($i=1, \ldots, X$) and the set of classes $\pi_{X+1}, \ldots, \pi_Y$ as follows:

$$\Psi(i, \varphi) = \sum_{j=X+1}^{Y} \Psi(i, j) \quad . \tag{5}$$

where j here is each class X+1 to Y.

- Total separability

$$\Psi = \sum_{i=1}^{X} \sum_{j=1}^{X} \Psi(i, j) + \sum_{i=1}^{X} \Psi(i, \varphi) \tag{6}$$

This value is the separability criterion employed in determining "best" subsets or linear combinations, as per subsequent sections.

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8.3.2.2.2 Without Replacement Procedure

The processor shall, on selection of the without replacement option, determine the minimum number of channels k required to satisfy the condition

$$\Psi/\Psi_k > 0.9$$

where Ψ = total separability derived from N channels, under the following guidelines.

A. Each single channel will be investigated as in Paragraph 8.3.2.2.1 with N replaced by 1 and only those class statistics in the channel employed. The minimum (extremum) of the calculated $\Psi_{(1)}$'s is selected as the optimum and the channel providing that value selected for (b).

B. Each remaining (N-1) channel is paired with the "best" channel, and the best $\Psi_{(2)}$ determined, again via Paragraph 8.3.2.2.1.

C. This process is repeated until $k \geq 4$ and $\Psi/\Psi_k > 0.9$ are satisfied.

D. Reports on all separability measures obtained from the channel subset k selected as "best" will be prepared as in Paragraph 8.3.2.2.1, as well as the ratio Ψ/Ψ_k.

8.3.2.2.3 FDP Iterator Option

On the selection of the FDP iterator option the program will have either a specified or unspecified channel set size for the output image generation. In the event the channel set is specified, a preliminary to the iteration process is an execution of the without replacement procedure of the previous paragraph with the distinction that no determination of separability ratios is made, only a selection of the best channel set at the specified level. If no specification of channel set size is made, the without replacement option is executed to determine the minimum channel set size satisfying the separability criterion.

In both cases the determined channel set from the without replacement procedure is employed as a starting matrix for the FDP search process, of dimension k x N.

This matrix, designated B, is modified until the separability values for the selected matrix have been optimized at level k.

The FDP interator is not described here; references are:

Requirements Document to Incorporate Linear Feature Selection Techniques Into The ERIPS, (EC-1403, NAS9-12200, November 1973)

and documents referenced therein.

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8.3.2.2.4 Image Transformations

The output of the linear combinations procedure is a k x N matrix, B, to be applied to each pixel of the object segment for creation of (1) a film product, where k=1 or k=3, and/or (2) a k dimensional image suitable for operations by the classification algorithm.

The transformation is

$$Y = BX$$

where X is the Nxl input measurement vector and Y is the Kxl output measurement vector.

The statistics used will be those related to the classification classes designated by the user. An error should be returned if the respective statistics have not been computed.

8.3.3.2 Maximum Likelihood Classification Computation

Each pixel of the field(s) to be classified will have a classification likelihood value (H_c) and a class (C) assigned to it. An H_c is computed for each class for each pixel and the pixel is assigned to the class which yields the H_c that provides the minimum probability of misclassification. The classification likelihood value is computed and used in the class decision making. The chi-square form of the value is extracted, transformed to an eight-bit integer and stored, i.e., accurate to about 1/2 of one percent for use by the display processor. The formulation for this process is as follows:

$$H_c = S_c + \sum_{i=1}^{N} \sigma_i \sum_{j=1}^{i} \Gamma_{ij}^{-c} \cdot \sigma_j \qquad (1)$$

where:

$$S_c = (R_c - P_c)$$

$$R_c = 1/2 \ln \left| \Gamma_{ij}^{c} \right|$$

$$P_c = \ln \rho_c$$

Γ_{ij}^{c} = the element of the covariance matrix for the C^{th} class representing the relationship between a pair (i, j) of channel data

$\left|\Gamma_{ij}^{c}\right|$ = the determinant of Γ_{ij}^{c}

Γ_{ij}^{-c} = the matrix inverse of Γ_{ij}^{c}

ρ_c = a priori constant for the C^{th} class

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$\sigma_i = \left(X_i - \mu_i^c\right)$

X_i = measurement vector in channel i

μ_i^c = mean in channel i of the C^{th} class

The measurement vector, X_i, is then assigned to the class, C, for which:

$$H_c < H_k \text{ for all } K \neq C \qquad (2)$$

8.3.2.2.5 Statistics Transformations

A rotated set of class statistics is to be obtained and employed by the classification processor when the linear combinations option has been exercised. This set of statistics shall replace the existing class statistics.

Using previous notation, the following values are to be calculated for each subclass for which statistics are defined.

$\mu_{ij} = B\mu_{ij}$

and $\Gamma_{ij} = B\Gamma_{ij} \; B^T$

where:

$i = 1, \ldots, X$

$j = 1, \ldots, j_i$

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8.3.3 Classification Processor

The Classification Processor will provide the user with the final desired result of the pattern recognition processor; i.e., the classifying of each pixel of a designated field(s) in to one of the specified training classes. The final assignment is made by evaluating the maximum likelihood equation shown below for each of the measurement vectors of the designated field(s) and assigning the pixel to the class that yields the maximum probability that the element belong to that class.

8.3.3.1 Inputs To The Classification Processor

To initiate the classification of the image being processed, the following input parameters must be specified.

A. Classification Classes. The individual classes into which the data is to be classified.

B. Class/Category Specification. The categories that are to be classified only to the class level.

C. Classification Channels. The channels to be used to classify each element of the image.

D. Classification Area. The portion of the image which is to be classified. This is designated by specifying the field names to be classified.

E. User specified a priori constants for each class/category. The processor will default to equal probability for all classes: i.e., the a priori values ρ_c as normally input will be 100/C, where C is the number of classes into which the data is to be classified. Possible inputs permitted for a priori specification are:

1. Value for all classes and $\Sigma\rho_c = 100$. The value used for the classification likelihood equation will be $\rho c/100$ for the appropriate Cth class.

2. Value for a subset of classes but $\Sigma\rho_c = 100$. The value used for the classification likelihood equation will be $\rho_c/100$ for the appropriate Cth class, however classes with no inputs will not be considered.

3. Value for a subset of classes and $\Sigma\rho_c < 100$. The value used for the classification likelihood equation will be $\rho_c/100$ for the appropriate Cth class, however the remainder of the classes will be assigned a value of $(100 - \Sigma\rho_c)/100C$; i.e., the remainder of the classes will assume equal probability of the remainder of the sumation.

4. Value for a subset of classes or for all classes but $\Sigma\rho_c > 100$. The value to be used when the summation is greater than 100 will be $\rho_c/\Sigma\rho_c$. If values were input for only a subset of classes, the classes which had no input will not be considered.

5. Category input of a priori values will be handled as in items 1 through 4, but will then be assigned equally over the class and subclass divisions; i.e., the ρ_c as computed above will be assigned the value ρ_c/MN for each subclass of the category, where M and N are the number of classes and the number of subclasses, respectively, in the category. This computation is performed only when utilizing the mixture density function classifier described in Paragraph 8.3.3.3.

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8.3.3.2 Classification Likelihood Computation

Each pixel of the field(s) to be classified will have a classification likelihood value (H_c) and a class (C) assigned to it. An H_c is computed for each class for each pixel and the pixel is assigned to the class which yields the H_c that provides the minimum probability of misclassification. The classification likelihood value is computed and used in the class decision making. The chi-square form of the value is extracted, transformed to an eight-bit integer and stored, i.e., accurate to about 1/2 of one percent for use by the display processor. The formulation for this process is as follows:

$$H_c = S_c + \sum_{i=1}^{N} \sigma_i \sum_{j=1}^{i} \Gamma_{ij}^{-c} \cdot \sigma_j \qquad (1)$$

where:

$S_c = (R_c - P_c)$

$R_c = 1/2 \ln \left| \Gamma_{ij}^{c} \right|$

$P_c = \ln \rho_c$

Γ_{ij}^{c} = the element of the covariance matrix for the C^{th} class representing the relationship between a pair (i, j) of channel data

$\left| \Gamma_{ij}^{c} \right|$ = the determinant of Γ_{ij}^{c}

Γ_{ij}^{-c} = the matrix inverse of Γ_{ij}^{c}

ρ_c = a priori constant for the C^{th} class

$\sigma_i = \left(X_i - \mu_i^c \right)$

X_i = measurement vector in channel i

μ_i^c = mean in channel i of the C^{th} class

The measurement vector, X_i, is then assigned to the class, C, for which:

$$H_c < H_k \text{ for all } K \neq C \qquad (2)$$

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The chi-square form is then extracted by the following:

$$Q_c = H_c - S_c; \text{ i.e., } Q_c = \sum_{i=1}^{N} \sigma_i \sum_{j=1}^{i} \Gamma_{ij}^{-c} \sigma_j \tag{3}$$

and transformed by:

$$I = \text{MIN}\,(A \cdot Q_c, 255) \tag{4}$$

where:

I = transformed eight-bit integer to be stored for use by the display processor

MIN = minimum function

Q_c is as above, equation (3)

A = prestored constant based on the number of channels used for classification. The table of values is as follows:

CHANNELS	A	CHANNELS	A
1	64.72	11	19.02
2	48.10	12	18.02
3	39.84	13	17.10
4	34.22	14	16.28
5	30.55	15	15.54
6	27.56	16	14.86
7	25.12	17	14.28
8	23.18	18	13.70
9	21.60	19	13.20
10	20.22	20	12.74

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8.3.3.3 Mixture Density Function Classification Computation

Classification, using the mixture density function, is performed in much the same way as for the maximum likelihood classifier. The main difference is that the statistics are carried at a lower level; i.e., the statistics corresponding to the class statistics of the maximum likelihood classifier are subdivided or refined to two lower levels. Therefore, the notation category (Z) class (C) and subclass (S) are used in this paragraph. The category level corresponds to the class level of the maximum likelihood and if class or subclass statistics were not extracted from the categories to be classified the mixture density function classifier would reduce to the maximum likelihood classifier. The same chi-square form is then computed and stored for use by the display processor and equates to the form corresponding to a subclass. This is because the densities of the mixtures (subclasses) are summed to the class level and then the classes to the category level and the only chi-square form that seems reasonable is the form computed for the most likely subclass of the decisive category. The option will exist to sum the density functions to the class level only or on to the category level. The formulation for this process is as follows.

Compute for each subclass the terms

$$P_s = \frac{\rho_z}{MN}$$

and $$R_s = \left|\Gamma_{ij}^{s}\right|^{1/2},$$

where:

ρ_z = a priori constant for the Z^{th} category

M = number of subclasses in the C^{th} class

N = number of classes in the Z^{th} category

Γ_{ij}^{s} = the element of the convariance matrix for the S^{th} subclass representing the relationship between a pair (i, j) of channel data.

Then compute the chi-square form as:

$$Q_s = \sum_{i=1}^{N} \sigma_i \sum_{j=1}^{i} \Gamma_{ij}^{-s} \sigma_j$$

where:

N = number of channels used to classify

$\sigma_i = (X_i - \mu^s_i)$

X_i = measurement vector in channel i

Γ_{ij}^{-s} = the matrix inverse of Γ^s_{ij}

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And store if, $H_s > H_{s-1}$

where:

$$H_s = (P_s E_s)/R_s$$

and $$E_s = \exp(-Q_s/2)$$

Then $H_c = \sum_{s=1}^{M} H_s$, where M is the number of subclass S in the class c.

If classification is performed only to the class level for this class then assign the measurement vector, X_i, to the subclass that yielded the H_s if:

$$H_c > H_k \text{ for all } K \neq C$$

and $$H_c > H_z \text{ for all } Z$$

If classification is to be performed to the category level, then compute the additional sum:

$$H_z = \sum_{C=1}^{N} Hc$$

where: N is the number of classes C in the category Z

and assign the measurement vector, X_i, to the subclass that yielded the largest H_s if:

$$H_z > H_c \text{ for all } C$$

and $$H_z > H_y \text{ for all } Y \neq Z$$

In each of the assignments above the name of the subclass, S, is stored that yielded the largest H_s and the associated Q_s is transformed by

$$I = MIN\ (A \bullet Q_s,\ 255)$$

where:

I = transformed eight-bit interger to be stored along with the subclass name for use by the display processor

MIN = minimum function

Q_s = as in equation (2)

A = prestored constant as in Paragraph 8.3.3.2 (same table values).

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8.3.3.4 User Designated Fields

As described for the Field Selection Processor (Paragraph 8.2.3.2), the user will have the capability to select designated fields. Specifically, the user may select two types of the designated fields; other and unidentifiable. These fields are to be assigned to the user designation regardless of the previous classification result. This special case will be handled as follows:

Using the previously stored subclass name, S, and a confidence level, Q_S. The smaller; i.e., closer to zero, the Q_S of a subclass the more assurance the observation vector was classified correctly. Therefore, after the classification process has been completed, the temporary work data set that was created to represent the subclass names and confidence levels will be searched for all designated fields of the recognition segment. The designated name and a confidence level of zero will be assigned to all pixels lying within these fields. The search will be done in the order of unidentifiable and then other; i.e., pixels lying in both designated unidentifiable and designated other will assume the name other. The resultant work data set will be utilized by the display processor for classification summary and imagery output.

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8.3.4 Display Processor

8.3.4.1 Display Processor Inputs

The Display Processor displays classification results for an image which has been classified. The following are necessary input for the display processor.

1. Desired mapping option. Options include color map, gray level map, character map (microfiche) and image tape.

2. Color values, gray level values, class characters and colors and intensities for image tapes.

3. User threshold values

4. Mensuration constants.

8.3.4.2 Display Processor Computations

The following computations will need to be made to implement the display processor:

A. Threshold Option. The user will specify a threshold percentage that the processor will utilize to look up in a table (ILIKE values versus percentages) an appropriate ILIKE value to be used to determine the null class. Zero percent will correspond to an ILIKE of 255 and 100 percent to zero ILIKE. Then for any classified pixel that has an I value (Paragraph 8.3.3.2) that falls above the ILIKE value, the null class will be assigned to that pixel for display purposes. Therefore, a threshold of zero percent (ILIKE=255) would cause no pixels to be assigned to the null class and a threshold of 100% would cause all pixels to be assigned to the null class.

B. Percentage. Simple percentages will need to be computed (no. sample X 100 percent/total no. sample).

C. Mensuration. If the mensuration option is selected, the display processor will need to multiply the number of samples classified into each class by the appropriate constant.

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8.3.4.3 Display Processor Outputs

The display processor wil' output two types of display output.

A. The Classification Map. The designated portion of the classified image will be output. Each element will be represented by a symbol, color, or gray level associated with the class that the element has been classified into.

B. Performance Tables. One line will be output for each field (training or test) plus one line for a set of totals for each type of field. Each line of data will contain the following:

1. Field ID

2. Class

3. Total number of samples in field or group

4. The percentage of the samples classified correctly into the class assigned to the field or group is also output.

5. Total number of samples classified into each group (a null group is added if a threshold was input).

C. Mensuration Tables. Mensuration output will contain the same information as listed for the performance tables, except that instead of number of samples output a mensuration value is output.

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8.3.5 Batch System Interface Processor

8.3.5.1 Purpose

The batch system interface processor will write an interface tape to be used as input to the CYBER 73 LARSYS for divergence, classification and display processing. The menus presented to the user for definition of the control card information are presented in paragraph 8.2.9. In addition to the control card information, the interface tape will contain image data. A detailed description of the format of this interface tape is presented in Section 10.0 of the Earth Resources Data Format Control Book. A summary of the data to be contained on this tape will be presented here.

8.3.5.2 Control Card Information

Each control card will be identified by a four-digit number. A particular control card need not be present and there may be multiple control cards for a particular four-digit identifier. A list of the identifiers and a summary description of the content follows.

0000	User comments and annotation
0100	Image information such as name, dimensions, channels and sensor identification
0101	Number of bits/pixel
0200	Field definition including name, type, class and class symbol
0201	Vertex definition of fields
0300	Class name and symbol for statistics
0301	Number of samples
0302	Mean value for a channel
0303	Covariance matrix
2000	Divergence processor information including channel set size, D(I,J) and D(MAX) excluded channels, and user specified channel set
2001	Classes to be considered for divergence computations
2002	Weighting factors
2003	D(IJ), D(MIN) values
2004	Class pairs affected by D(I J), D(MAX) values

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2004	Class pairs affected by D(I,J), D(MAX) values
2005	Ranking criterion for divergence processor
3000	Classification channel set definition
3001	Classes to be calssified and threshold values
3002	Fields to be calssified
4000	Type output; 1 in column 9 = printout, 1 in column 10 = microfiche, 1 in column 11 = DAS

8.3.5.3 Image Data

The image data will follow the control card information and will be limited to ten million bytes with a maximum of 1000 elements or pixels per scan line. Maximum block size will be 3840 bytes and the image formats may be in multiple lines per block, multiple blocks per line or one line per block. A line is defined here as a scan line for all channels, i.e., a 1000 byte scan line for five channels would be a total of 5000 bytes and require two blocks per line. This means a line may not begin in a block if it cannot be completed in that block.

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8.3.6 Signature Extension Processor

8.3.6.1 Fields Only

The Signature Extension Processor can checkpoint only fields at the user's request. When the Signature Extension option is specified, the program will only check the boundaries of the loaded image for inclusion of all checkpointed fields and not the number or compatibility of channels.

8.3.6.2 Statistics Only

The user may opt to checkpoint class statistics only at checkpoint time. Then when the Signature Extension option is selected, the program will only check compatibility of the channel configuration of the loaded image and not the boundaries.

8.3.6.3 Fields and Statistics

The program Signature Extension logic will have to check both the channel configuration and the boundaries of the loaded image when the user has elected to checkpoint both fields and statistics. All of the options, Fields Only, Statistics Only, and Fields and Statistics, require the storing of Signature Extension data in order that all Pattern Recognition Processors can access the data for further processing.

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8.3.7 Goodness of Fit Processor

8.3.7.1 Inputs to the Goodness of Fit Processor

The following user inputs are required to initiate the Goodness of Fi. Processor.

A. The class, field, or cluster to be tested.

B. Channels of the class, field, or cluster to be used.

C. Test to be performed, i.e., Pearson Chi-Square or Komolgorov Smirnov Test.

D. Statistics of field, class, or cluster.

E. Intervals, if the Pearson Chi-Square Test is selected.

8.3.7.2 Pearson Chi-Square Test

Using μ_i and Γ_{ij} computed from the Statistics Processor or clustering application form compute:

$$Q = \sum_{i=1}^{N} \sigma_i \quad \sum_{j=1}^{i} \Gamma_{ij}^{-1} \sigma_i$$

for the collection of data points to be analyzed.

where:

N = number of channels

$\sigma_i = (\chi_i - \mu_i)$

χ_i = measurement vector in channel i

Γ_{ij}^{-1} = covariance of the field, class, or cluster to be tested.

Then apply the Pearson Chi-Square Goodness of Fit Test to the chi-squared distribution of Q values as follows:

A. Fix number of intervals, K, for partition of Q values

B. Fix interval endpoints based upon

1. Equidistant intervals or,

2. Equally populated intervals.

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C. Partition the Q values for each interval to determine the theoretical population, P_{Ti}, and observed population, P_{oi}.

D. Then form:

$$G = \sum_{i=1}^{K} \frac{(P_{oi} - P_{Ti})^2}{P_{Ti}}$$

E. Output the value of G and its percentile in the chi-squared distribution for K-1 degress of freedom.

8.3.7.3 Kolmogorow-Smirnov Test

From the chi-squared distribution of Q values, Paragraph 8.3.7.2, apply the Kolmogorow-Smirnov Goodness of Fit as follows

A. Find $L_i = \int_{o}^{Q_i} \chi_n^2 \; d\, \chi_n^2$

where: i = 1, 2, 3 ...N intervals

B. Find $K_i = \max \left[\left| L_i - \frac{i}{n} \right| , \left| L_i - \frac{i-1}{n} \right| \right]$

C. Output $K_{max} = \max\ [K_i]$

D. Output percentile equals:

$$2 \sum_{j=1} (-1)^{j+1} \epsilon^{2j^2} N^2 K_{max}^2$$

For more information concerning both goddness of fit algorithms see NASA JSC Internal Note 73-FM-63, dated May 4, 1973.

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8.4 OUTPUTS

8.4.1 General

This section describes the outputs of the LARS program in the areas of imagery, graphic data and digital data. The imagery displays will appear on the imagery television screen in 16 levels of gray and/or on the color television screen, while the graphic data and digital data will appear on the conversational television screen in black and white. All reports will be made available for display as requested by the user. In addition, all reports will be available for retrieval upon request under the following conditions:

A. The user has not exited the applications program that computed the display; i.e., pattern recognition.

B. New data has not been requested by the user; i.e., if new training regions have been defined and statistics data recomputed, then the previous statistics data is no longer available.

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8.4.2 Imagery

8.4.2.1 Graymaps

Graymaps may be used for two purposes during pattern recognition processing:

A. Initially for the user's visual inspection and training field(s) definition and

B. For the final classification map.

8.4.2.2 Initial Graymaps

The graymap for the initial training field(s) definition will be generated by the Image Manipulation and Display Processor using one of the gray level determination methods of Paragraph 6.3.3.

8.4.2.3 Classification Maps

Classification maps may be generated on the 16 levels of gray television screen, on the eight color television screen, as a character map to microfiche, or as an image tape. The user will have the option of specifying gray levels and colors or using a computer default set. If the user opts to have the classification printed he must enter the symbols to be used for the classes. The Class map will depict visually the correspondence between the class membership and spatial location of any given pixel in the image. Classified Fields may be displayed simultaneously in proper geographical context relative to the overall image. See Figure 8.4.2.3-1.

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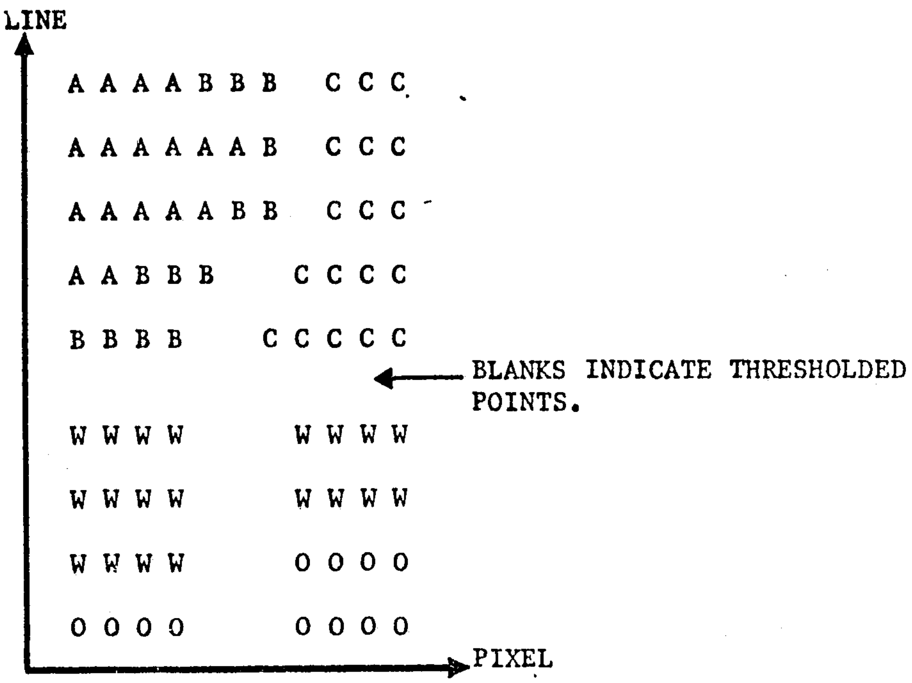
(a) Contiguous Image Clustered



(b) Field Subsets Clustered

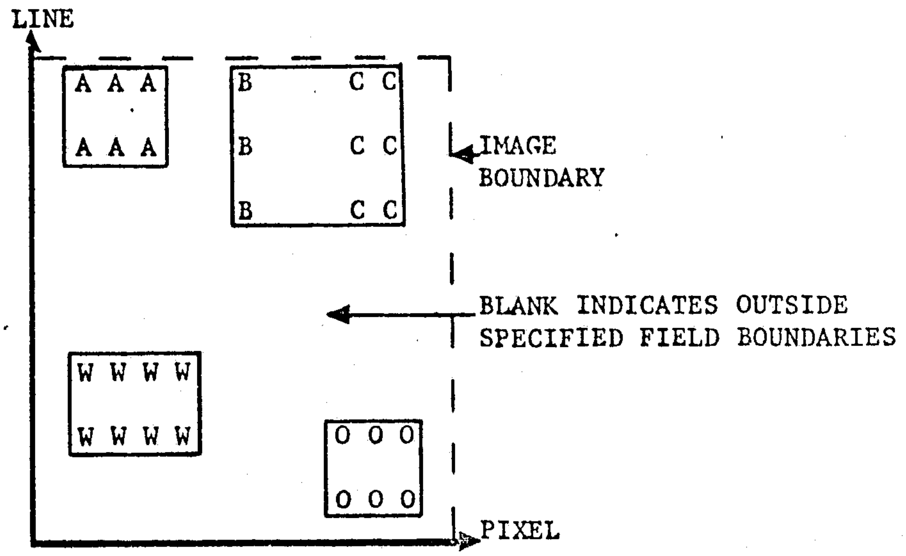


Figure 8.4.2.3-1 Illustration of Class Maps (Character Option)

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8.4.3 Graphic Data

8.4.3.1 Histogram Plots

Histogram plots will be displayed on the conversational television screen upon request to determine the validity of the Gaussian distribution assumption. The histogram plots will express the percentage (maximum scale of 50 percent) of total elements of a training field or a group of training fields (class) versus a particular relative radiance as a line graph. The relative radiance scale will increase to the right regardless of the direction of increasing brightness. There will be up to four histogram line graphs per plot for up to four classes and one channel. If the user has elected to expand (i.e., blow up or specify the scaling) this plot, an indicator with the percentage of total points under all four curves that is outside the scale will be displayed. Also, the total number of points in each class will be listed with the class name. An example of the histogram plot is shown in Figure 8.4.3.1-1. There will be Reseau Marks on the histogram plot to aid visual interpolation accuracy. If the amount of data required to display four histogram line graphs results in an overflow condition, the user will be notified and requested to specify fewer histograms.

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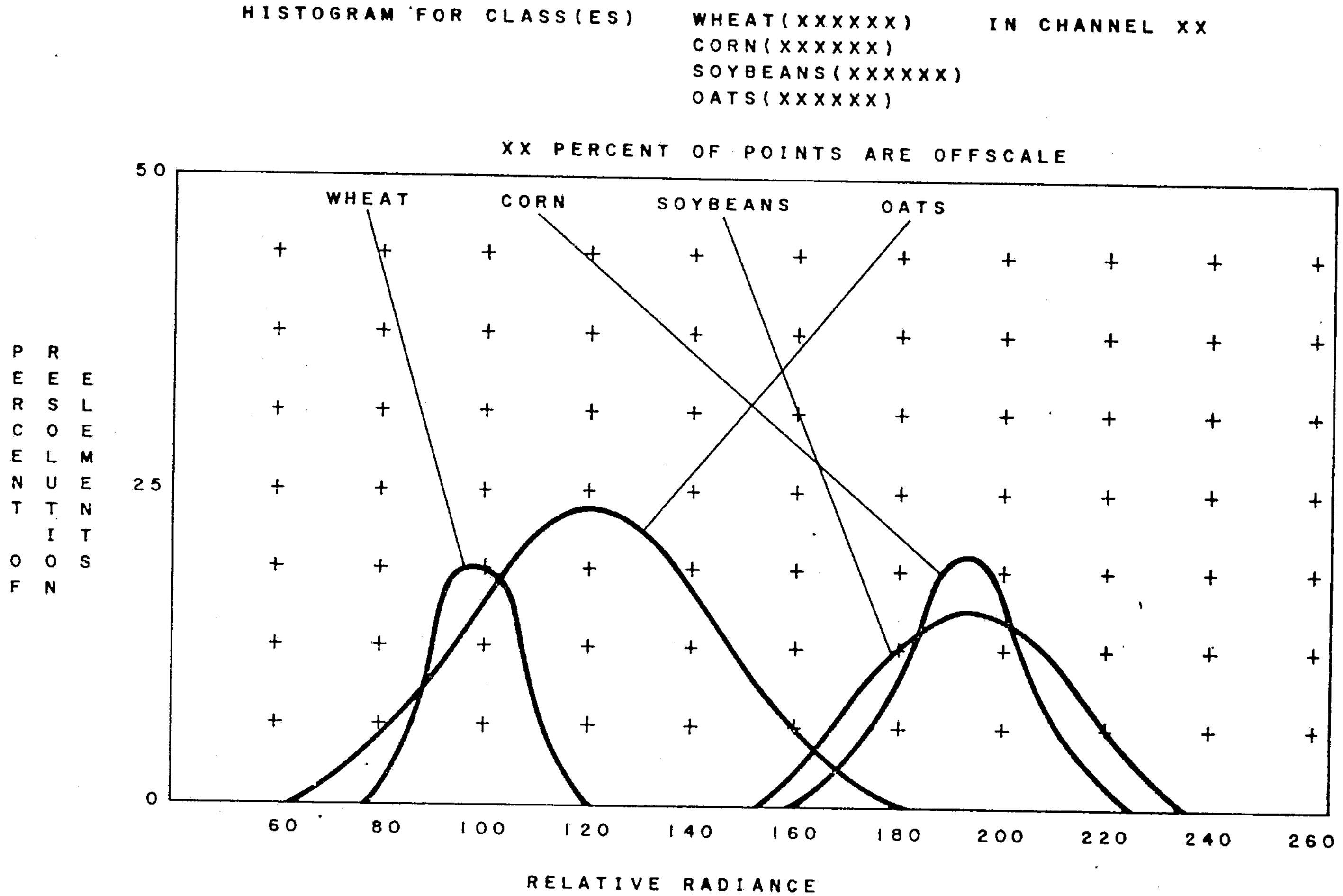

Figure 8.4.3.1-1 Histogram for Classes

8.4.4 Digital Data

8.4.4.1 Mean-Standard Deviation

A request to view the computed means and standard deviations will result in a report on the conversational television screen as illustrated in Figure 8.4.4.1-1. The channels will be listed in the first column with the means and standard deviations in each of the channels for up to four classes or training fields listed in columns to the right of the channels. The total number of elements in each class or field will be listed under the class or field name. In the field columns the class name to which the field belongs will be listed under the number of elements in the field. The user will have the option with this report to view all classes, all training fields or both. When requesting data for more than four classes and/or training fields the user will have the capability to page to observe the complete set of data.

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MEAN AND STANDARD DEVIATION
FOR CLASSES AND TRAINING FIELDS
AND ALL CHANNELS

CHANNEL NUMBER	CLASS XXXXXX (XXXXXX) MEAN	ST DEV	CLASS XXXXXX (XXXXXX) MEAN	ST DEV	CLASS XXXXXX (XXXXXX) MEAN	ST DEV	FIELD XXXXXX (XXXXXX) CLASS XXXXXX MEAN	ST DEV
1	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX

Figure 8.4.4.1-1 Mean and Standard Deviations

8.4.4.2 Divergence Processor Displays

In order to compact the display of the best channel sets and the interclass divergence values, the first display available to the user from the divergence processor will be the list of the 30 best channel sets as determined by the divergence processor (see Figure 8.4.4.2-1). If any user-specified channel sets are contained in the best 30 channel sets, they will be flagged with an asterisk, see ranking No. 10 in Figure 8.4.4.2-1.

Following the Best 30 Channel Sets will be the detailed interclass divergence values for all 30 sets in Figures 8.4.4.2-2, 8.4.4.2-3, and 8.4.4.2-4. The user will have the capability to page and observe interclass divergences for all class pairs.

If the user has specified any special channel sets, the sets will be listed as the last entries in the top 30 best sets, and if they appear in the 30 best sets marked with an Asterisk and not repeated; i.e., if the user specifies five sets they would appear in position 26 to 30 unless one or more were included in the top thirty.

8.4.4.3 Classification Summary Display

The classification summary display will contain data relating to the performance of the classification processor. The display first page (Figure 8.4.4.3-1) will identify the image from which the data was generated followed by a list of category/class/subclass names that were considered during classification (the symbol will be listed also) and the corresponding percent threshold values and a priori constants. The channels used to perform the classification will be the final column on the first page.

Then, on the second and following pages will be a list of individual training and test fields with their classification summary results. Groups of training fields for a class will be totaled as well as groups of test fields. Columns of data on these pages will list (as shown in Figure 8.4.4.3-2) the field ID, the class name, number of samples in the field, percent correct classification (number of samples classified into the class assigned to the field divided by the number of samples in the field times one hundred), and the number of samples classified into each class. A page capability will exist to observe all classes and all fields.

Alternatively, if the mensuration option had been selected on the Classification Summary Report Menu, the 'numbers of samples' values throughout the display shall be replaced by area measurements reflecting the parameters input on the Mensuration Report Menu. The display shall also indicate the units and scaling from the Mensuration Menu.

When operating in the LACIE mode (using mixture density function) the category/class/subclass names will be listed left to right; i.e., the category name will be listed followed by the first class in the category and then the subclasses within that class. Then the second class in the category will be listed followed by the subclasses in the second class and so on until that category's subdivisions are exhausted. The second category will be listed next, organized in the same order as above. This sequence will be continued until all categories are exhausted.

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```
COMPUTED BEST CHANNEL SETS
WITH RANKING BASED ON D(AVE)
.
  1. XX,XX,XX,XX,XX,XX,XX,XX
  2.
  3.
  4.
  5.
  6.
  7.
  8.
  9.
* 10.
 11.
 12.
 13.
 14.
 15.
 16.
 17.
 18.
 19.
 20.
 21.
 22.
 23.
 24.
 25.
 26.
 27.
 28.
 29.
 30. XX,XX,XX,XX,XX,XX,XX,XX
```

Figure 8.4.4.2-1 Computed Best Channel Sets

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MINIMUM=XXX

INTERCLASS DIVERGENCE TABLE
WITH RANKING BASED ON D(AVE)
BEST SPECTRAL BAND SETS

MAXIMUM=XXX

	1.	2.	3.	4.	5.	6.	7.	8.	9	*10.
D(AVE)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
D(MIN)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AB(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AC(10)										
AD(10)										
AE(10)										
AF(10)										
AG(10)										
AH(10)										
AI(10)										
AJ(10)										
AK(10)										
AL(10)										
AM(10)										
AN(10)										
AO(10)										
AP(10)										
BC(10)										
BD(10)										
BE(10)										
BF(10)										
BG(10)										
BH(10)										
BI(10)										
BJ(10)										
BK(10)										
BL(10)										
BM(10)										
BN(10)										
BO(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Figure 8.4.4.2-2 Interclass Divergence Table (1 through 10)

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Approved: ______ NASA/DPB ______ PHO

MINIMUM=XXX

INTERCLASS DIVERGENCE TABLE
WITH RANKING BASED ON D(AVE)
BEST SPECTRAL BAND SETS

MAXIMUM=XXX

	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
D(AVE)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
D(MIN)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AB(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AC(10)										
AD(10)										
AE(10)										
AF(10)										
AG(10)										
AH(10)										
AI(10)										
AJ(10)										
AK(10)										
AL(10)										
AM(10)										
AN(10)										
AO(10)										
AP(10)										
BC(10)										
BD(10)										
BE(10)										
BF(10)										
BG(10)										
BH(10)										
BI(10)										
BJ(10)										
BK(10)										
BL(10)										
BM(10)										
BN(10)										
BO(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Figure 8.4.4.2-3 Interclass Divergence Table (11 through 20)

MINIMUM=XXX

INTERCLASS DIVERGENCE TABLE
WITH RANKING BASED ON D(AVE)
BEST SPECTRAL BAND SETS

MAXIMUM=XXX

	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
D(AVE)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
D(MIN)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AB(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
AC(10)										
AD(10)										
AE(10)										
AF(10)										
AG(10)										
AH(10)										
AI(10)										
AJ(10)										
AK(10)										
AL(10)										
AM(10)										
AN(10)										
AO(10)										
AP(10)										
BC(10)										
BD(10)										
BE(10)										
BF(10)										
BG(10)										
BH(10)										
BI(10)										
BJ(10)										
BK(10)										
BL(10)										
BM(10)										
BN(10)										
BO(10)	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Figure 8.4.4.2-4 Interclass Divergence Table (21 through 30)

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```
                         DETAILED CLASSIFICATION SUMMARY

                               IMAGE=XXXXXXXXXXXX
                    MENSURATION SCALING=XXX.XXXX ACRES/PIXEL                    CHANNELS
CATEGORY  SUBCLASS  PERCENT  A PRIORI  CATEGORY  SUBCLASS  PERCENT  A PRIORI  CONSIDERED

   X       XXXXXX    XXX.X     XXX        X       XXXXXX    XXX.X     XXX         XX
   |          |        |        |         |          |        |        |          |
   X       XXXXXX    XXX.X     XXX        X       XXXXXX    XXX.X     XXX         XX
```

Figure 8.4.4.3-1 Detailed Classification Summary

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CLASSIFICATION SUMMARY

```
FIELD     NO OF  PCT.  XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX
 ID/      SAMPS  CRCT
CLASS
NAME
                       XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX

XXXXXXX  XXXXXX  XXX.X XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX
XXXXXX

                       XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX

XXXXXXX  XXXXXX  XXX.X XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX
XXXXXX

                       XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX

TOTAL FOR TRAINING FIELDS-XXXXXX
         XXXXXX  XXX.X XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX

                       XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX
```

Figure 8.4.4.3-2 Classification Summary

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8.4.4.4 Field Definition Display

The user may request at any time during processing a display of the field definitions (training fields, test fields or any miscellaneous fields). A sample of this output is shown in Figure 8.4.4.4-1. The columns of data will list the field ID and subclass, the type of field (training, test, other) as a symbol, the category symbol and the vertices (up to 10) of the fields. The vertices will be defined by line and column numbers. A page capability will exist to allow observation of all field definitions.

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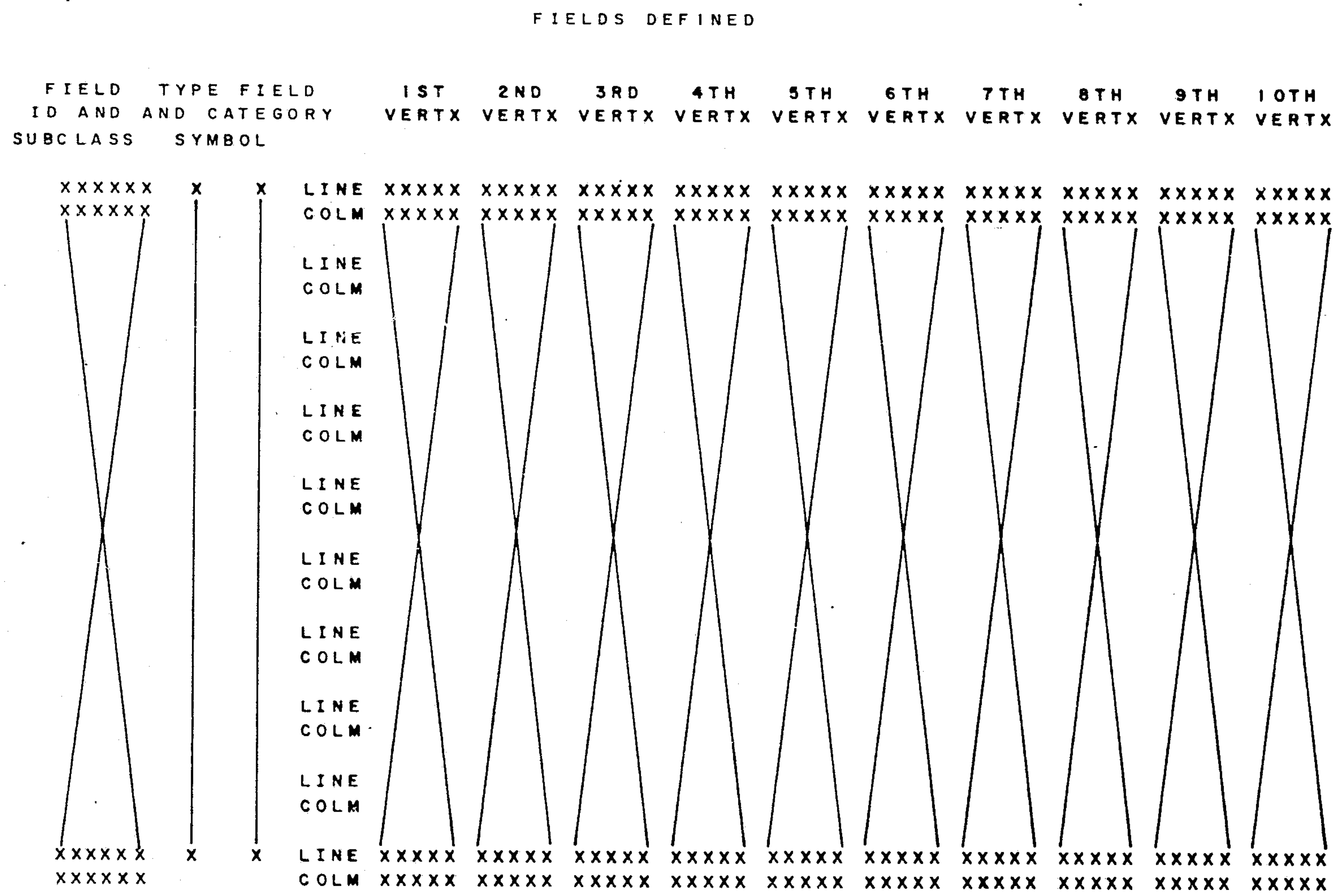

Figure 8.4.4.4-1 Training Region Display

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SECTION 9

DATA CLUSTERING REQUIREMENTS

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SECTION 9

DATA CLUSTERING REQUIREMENTS

9.1 INTRODUCTION

9.1.1 General

Data Clustering, as a generic class of techniques, has been used by various statistically-oriented disciplines since the 1930's to separate distributed "population" samples into discrete subsets according to similarities in certain specified attributes, or features. More recently, investigators studying the classification of ground features from multispectral imagery have discovered the applicability of clustering data points in multispectral "feature-space." This concept has immediate potential as an adjunct to the LARSYS technique (see Section 8) since it provides a means for evaluating the data structure of supposedly homogeneous "training fields", as well as, providing an alternate source of "training" statistics. Data Clustering also has future potential for so-called "unsupervised classification" whereby features are first categorized without benefit of "a priori" class information, then assigned to classes by comparing a geographically correlated Cluster Map to known ground features. ERIPS clustering will be designed first to optimize the interactive use of clustering as an adjunct to LARSYS; and second, to provide the analytical capability necessary to allow pursuit of the latter goal of "unsupervised classification."

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9.1.2 Program Description

The CLSTR Program will function either as a stand-alone program or as an adjunct to LARSYS. However, in either case it will be selected from within the Pattern Recognition Program, using the Pattern Recognition Processor Selection Menu, (see Figure 8.2.2.2-1) because of systems considerations. CLSTR will be subject to the same input data set constraints as Pattern Recognition (PR).

Two basic options will be provided:

- An ITERATIVE Algorithm which may be either "self-starting" or started using externally provided statistical parameters.
- An ADAPTIVE Algorithm, while theoretically less optimal than the iterative technique, requires much less time to reach an acceptable (for many purposes) solution.

Along with the choice of Algorithm, the user will be provided with menu inputs (see Paragraph 9.2 "User Interface Requirements") allowing to choose from available "starting" options and to specify appropriate program control inputs (thresholds, number of clusters desired, number of iterations desired, etc.). The user will also be given a choice of clustering "fields" (as defined in Paragraph 8.2.3.2) or "classes" (consisting of all fields assigned a common class name). CLSTR will have the capability to use field definition and channel selection information previously generated in PR and/or to arrive at this information starting from CLSTR. Similarly, CLSTR will be able to use PR-generated class statistics as an input, and/or to generate these statistics for output to PR. The user shall have the capability to add clusters to, or delete from, the class statistics table. Because of the symmetry between CLSTR and PR, the conventions and constraints regarding the maximum number of classes (60), the naming of classes, and the assignment of class symbols and/or gray/color levels for output will apply likewise to clusters.

For the ITERATIVE Algorithm, the user will have the capability to manually force additional iterations following completion (as per input value) of the automatic iteration loop. For both algorithms, the user will be provided with evaluation displays (see Paragraph 9.2) giving current information on the individual cluster statistics, "distance" between clusters, and cluster "dynamics" (merging and splitting of clusters from one iteration to the next). Information will also be provided on which classes (or previously entered clusters) in the PR class statistics table most closely match newly computed clusters.

For the ADAPTIVE Algorithm, the user will be provided with appropriate error messages and diagnostic and recovery capabilities sufficient to detect (and recover from) anomalous program performance (such as getting stuck in a "loop").

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The final output of the CLSTR program will consist of: (1) cluster means, standard deviations, and convariances (consistent with LARSYS input requirements), and/or (2) a cluster map. The cluster map will be exactly analogous in concept to the classification map defined in Paragraph 8.4.2.3. It will depict visually the correspondence between the cluster membership and spatial location of any given pixel in the image. Areas which contain points belonging to a cluster will be displayed in proper geographical context relative to the overall image, and displayed in up to 16 levels of gray or 64 colors. Gray/color assignments will be a user input. The cluster map may be output to microfiche in up to 60 cluster symbols (the same 60 used for class symbols). See Figures 8.4.2.3-1 and 8.2.7.2-1.

The user will have the capability to modify the cluster map output as follows:

- Gray/color/character assignments (as exists in PATTERN RECOGNITION).
- Thresholding out of "loosely clustered" points (similar to PR thresholding of "loosely classified" points).
- CHAINING (or display grouping) of clusters which are within a (user-specified) distance from one another.

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9.2 USER INTERFACE REQUIREMENTS

9.2.1 General Capabilities

All menus presented to the user in the CLSTR application will include capabilities: to scroll the image(s), to select the image manipulation and display application, and, via error recovery logic, allow unloading and scratching from disk, all without exiting from the CLSTR application. Also, the capability will exist to indicate the EOF (End-of-Field) and EOT (End-of-Transmission) on all menus without use of the keyboard. The user may return to the previous menu by indicating a return on any of the menus in this application.

All displayed images in this application will include on the overlay a position indicator (line & column) of the upper right hand corner and the lower left hand corner. The corner positions will be updated as the image(s) scroll is halted.

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9.2.2 Processor Selection

The CLSTR program will be selectable as one of the options included in the Pattern Recognition processor selection menu (see Figure 8.2.2.2-1). Upon selection of CLSTR, the operator will be presented with the selection menus (see Figures 9.2.2.1-1, 9.2.2.1-2, and 9.2.2.1-3).

9.2.2.1 Clustering Selection Menus

9.2.2.1.1 Clustering Channel Selection Menu

This menu shall provide the user channel selection with the following entries (see Figure 9.2.2.1-1):

A. ALL — All 30 channels selected.

B. Subset of channels may be selected by cursoring the numbered channel(s) boxes.

C. Best channels set from; DAVE, DMIN,or DIJ.

9.2.2.1.2 Clustering Area Definition Menu

This menu shall provide the user with the following entries (see Figure 9.2.2.1-2):

A. FIELD AND/OR CATEGORY/CLASS/SUBCLASS NAME TO BE CLUSTERED — Entries must be made consistent with the names used in the field definition processor (Paragraph 8.2.3) or read from the fields data base. When operating in the LACIE mode, the user may input category/class/subclass names. Input of category or class names will cause all subclasses in that category or class to be clustered. Of course, individual subclasses may be input to be clustered.

B. SKIP FACTOR — This is an option to skip lines and/or pixels to be clustered. For example an entry of 10 in the LINE field and 5 in the PIXEL field will indicate clustering every 5th point of every 10th line within the defined fields.

9.2.2.1.3 Clustering Initialization Menu

This menu shall provide the user with the following entries (see Figure 9.2.2.1-3):

A. RUN NO. This is an operator incremented number to identify repeated passes through clustering with updated initialization data. An entry of zero will clear the menu and re-initialize all clustering reports.

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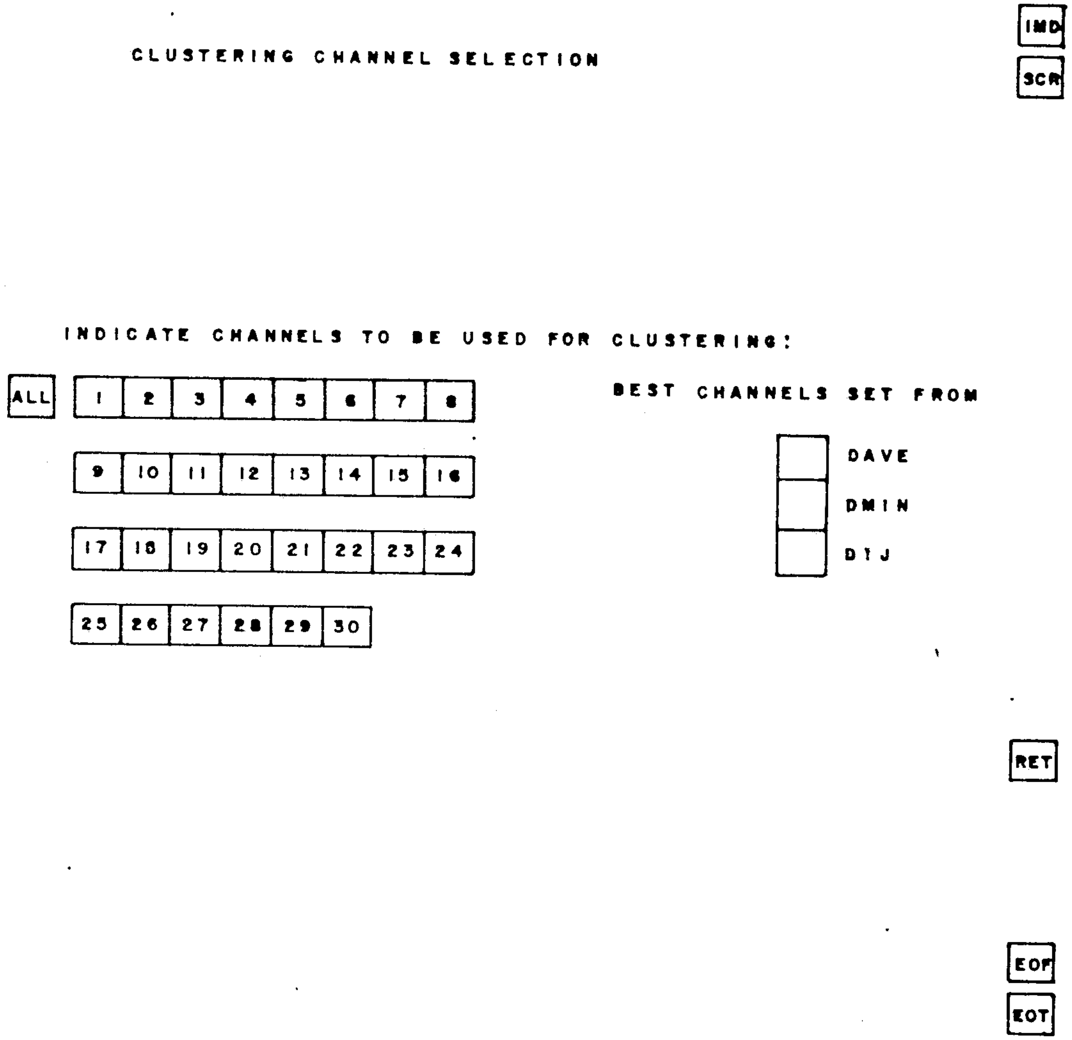

Figure 9.2.2.1-1 Clustering Channel Selection

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IMD SCR RET EOF EOT

CLUSTERING AREA DEFINITION MENU

ENTER FIELD AND/OR CLASS NAME TO BE CLUSTERED:

___ ___ ___ ___
___ ___ ___ ___
___ ___ ___ ___
___ ___ ___ ___
___ ___ ___ ___

SKIP FACTOR:

LINE ___

PIXEL ___

Figure 9.2.2.1-2 Clustering Area Definition Menu

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B. Initialization parameters, as defined and specified in JSC MPAD IN 72-FM-268 Rev 1, dated 23 April 1973 are:

1. MAXIMUM NUMBER OF CLUSTER - NV MAX.

2. STRIP GENERATION PARAMETER - S

3. In the column under ADAPTIVE option:

- C - A cluster merging threshold.
- R1 - Value of the refinement parameter R for the 1st iteration.
- R2 - Value of the refinement parameter R for the 2nd iteration.
- M1 - Multiplier of R1, $0 > M1 \geq 1$.
- NMIN1 - Threshold for eliminating small clusters.
- NET - A test threshold for cluster elimination.
- NMT - Merge frequency, i.e., merge every NMT data points.
- NPT - Cluster update priority frequency.
- STATISTICS - Option to compute cluster Statistics on remaining channels (those not selected on Clustering Channel Selection Menu).

4. In the column under ITERATIVE option:

- PERCENT - Initial cluster splitting threshold. If percent is 0, then the Split/Combine Sequence will be followed. If percent is greater than zero and less than or equal to 100, split until percent of clusters satisfies STDMAX, then use the Cluster Summary Report menu sequence (Paragraph 9.2.2.2).
- SEP - A splitting parameter denoting the number of sigmas to separate the two new clusters from the mean of the original cluster, thus, for a given channel:

  New Mean 1 = Old Mean + SEP X Sigma
  New Mean 2 = Old Mean - SEP X Sigma

- STDMAX - Threshold sigma for splitting clusters. Cluster will be split if sigma STDMAX.

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- DLMIN – Threshold for merging clusters
- NMIN 2 – Threshold for eliminating small clusters
- ITMAX – Maximum number of iterations allowed in initializing iterative cluster using P option.
- SPLIT/COMBINE SEQ – S/C SEQ (max of 8 characters) to be followed, if, PERCENT is zero, or after ITMAX satisfied, or after PERCENT satisfied.
- STATISTICS – Option to compute cluster Statistics on remaining channels.

5. REACESS – An option to reacess a specific run. The run number should be specified in the RUN NO. field.
6. STARTING VECTORS – Selection of the starting vectors may be made from the following options:
   - SELF GENERATING VECTORS
   - CLASS STATISTICS VECTORS
   - VECTORS FROM RUN NUMBER
   - EXTERNAL VECTORS

C. DEFAULT OPTIONS – The user will have the option to choose one of two default sets of initialization parameters on this menu via the boxes labeled DEFAULT1 and DEFAULT2. The values to be used in each case are given below.

DEFAULT1

Maximum number of clusters 10
Strip Generation Parameter 5
Select ITERATIVE option and input the following:
Percent 0.8
SEP 1.0
STDMAX 3.2
DLMIN 3.2
NMIN2 II*N
ITMAX 5
Split combine sequence SC
Select STATISTICS Box
Select CLASS STATISTICS VECTORS Box

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CLUSTERING INITIALIZATION MENU

DEFAULT 1 ☐ 	IMD 	SCR

RUN NO.

DEFAULT 2 ☐

MAXIMUM NUMBER OF CLUSTER ____

STRIP GENERATION PARAMETER ____

☐ ADAPTIVE 	☐ ITERATIVE 	☐ REACESS

C	____	PERCENT	____	RUN NO.	____
R1	____	SEP	____		
R2	____	STDMAX	____		
M1	____	DLMIN	____		
NMIN1	____	NMIN2	____		
NET	____	ITMAX	____		
NMT	____	SPLIT/COMBINE SEQUENCE:			
NPT	____	____			

☐ STATISTICS 	☐ STATISTICS 	RET

STARTING VECTORS ☐ SELF GENERATING VECTORS ☐ EXTERNAL VECTORS

☐ CLASS STATISTICS VECTORS

☐ VECTORS FROM RUN NUMBER ____

EOF

EOT

Figure 9.2.2.1-3 Clustering Initialization Menu

IMD

SCR

CLUSTER REPORT MENU

CLUSTER	POPULATION	CLASS MATCH	DISTANCE	CLUSTER MATCH	DISTANCE	NAME	CANCEL
1	XXXXX	XXXXXX	XXX.X	XXXXXX	XXX.X	____	__
2						____	__
3						____	__
4						____	__
5						____	__
6						____	__
7						____	__
8						____	__
9						____	__
10						____	__
11						____	__
12						____	__
13						____	__
14						____	__
15						____	__
16						____	__
17						____	__
18						____	__
19						____	__
20	XXXXX	XXXXXX	XXX.X	XXXXXX	XXX.X	____	__

RET

☐ GOODNESS OF FIT

☐ DETAILED REPORT ☐ DISTANCE TABLE ☐ CHAINING ☐ MAP GENERATION

☐ REJECT RESULTS AND RECOVER ☐ END RUN, STORING STATISTICS

☐ FORCE ITERATIVE SEQUENCE ☐ WITH STATISTICS

____

EOF

EOT

Figure 9.2.2.2-1 Cluster Report Menu

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6. MAP GENERATION – An option to request map generation. Selection of MAP GENERATION will provide a subsequent menu which allows the user to select the type of map; color, gray-level, image tape, or character map. When the user selects the map type, an additional menu will be displayed allowing the user to select; levels, colors, or characters with thresholds for the clusters, see paragraph 8.2.7. The user may call IMD for display of the color or gray level maps.

7. REJECT RESULTS AND RECOVER – An option to reject results and recover may be used if, e.g., a forcing of an interative sequence produced undesired results, and the user desired to try a different sequence.

8. FORCE INTERATIVE SEQUENCE – An option to force an interative sequence typed in by the user. The user would have had to make the necessary entries for interative algorithm in the initialization menu.

9. WITH STATISTICS – An additional option if FORCE INTERATIVE SEQUENCE is selected.

10. GOODNESS OF FIT – An option to call the Goodness of Fit processor (paragraphs 8.2.11 and 8.3.7) for the clusters with an entry of G in the CANCEL column.

11. END RUN, STORING STATISTICS – Terminates run and returns to clustering Initialization Menu with next Run Number. If STATISTICS option had been selected for current Run and Clusters had been named, then statistics were stored in the class Statistics Table. Any clusters to be CANCELLED are done so at this time.

9.2.2.3 CLSTR Chaining Menu

This menu will allow the user to generate and view a display of inter-cluster grouping as determined by a user-input distance threshold. This menu will be callable from either the Cluster Summary Report (Paragraph 9.2.2.2) or the Inter-Cluster Distance Table (Paragraph 9.4.4.2). Following the user's entry of the distance threshold, the program will determine which clusters could be connected in a "chain" with "links". The clusters belonging to a given chain will be displayed (by cluster number) in a line across the display, one line for each chain.

The user will be provided with an input to name each chain and to call up the PR Class Map Menu (Figure 9.2.2.3-1). The map MENUS for assigning gray/color/character symbols will appear with the chain names previously entered in the chain menu, so that the user may conveniently assign common symbols to chained clusters.

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```
CLUSTER CHAINING MENU                         RUN NUMBER = XX
 CHAINING THRESHOLD.TYPE IN,HIT EOT ____
   CHAIN NUMBER(DOWN)CONTAINS CLUSTERS(ACROSS)       TYPE IN CHAIN NAME     IMD
   1.XX/XX/XXXXX/ / / / / / / / / / / /                     ______
   2.
   3.
   4.
   5.
   6.
   7.
   8.
   9.
  10.
  11.
  12.                                                                       MAP
  13.
  14.
  15.
  16.
  17.
  18.
  19.
  20.
  21.
  22.                                                                       RET
  23.
  24.
  25.

                                                                            EOF
                                                                            EOT
```

Figure 9.2.2.3-1 Cluster Chaining Menu

9.3 PROCESSING REQUIREMENTS

9.3.1 General

The mathematical algorithms for performing clustering as described herein will be as documented in JSC Internal Note Number 72-FM-268. MPAD, Rev 1, dated 23 April 1973. The ERIPS Software Contractor will adhere to the Internal Note subject to the following guidelines:

A. The "end results" visible to the user will be consistent with the Internal Note subject to system limitations and/or waivers negotiated with the MPAD and EOD.

B. Subject to guideline A above, the detailed math flow expressed in the Internal Note may be altered to conform to ERIPS system characteristics.

C. The user interface requirements expressed in Paragraph 9.2 supercede those expressed or implied in the Internal Note. Any critical differences should be resolved during the review period of PHO-TR514, Section 9, Data Clustering Requirements.

D. The chaining algorithm to be used is described in Paragraph 8.3.1.5.

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9.3.2 Cluster Map

The general features of the cluster map have been described in Paragraphs 9.1.2 and 9.2.2.2. An additional capability, as specified by JSC Internal Note Number 72-FM-268, will be to "threshold" data points of the image array prior to display. This may be accomplished by use of existing (properly modified) PR Menus in Figures 8.2.7.3-1, 8.2.7.4-1, 8.2.7.5-1, and 8.2.7.6-1.

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9.4 OUTPUTS

9.4.1 General

This section describes the outputs of the CLSTR application in the areas of imagery, graphic data and digital data. The general features of the image and conversational video displays will be as described elsewhere in this document and in the "ERIPS FUNCTIONAL SPECIFICATION" document. In addition to video displays, the system will provide for printer hardcopy output of digital/graphical displays and microfiche hardcopy of imagery data.

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9.4.2 Imagery

9.4.2.1 Output Image to Tape

Images, e.g. cluster maps, generated in the CLSTR application may be output to tape by using the LOAD application (Section 5). This may be done without exiting CLSTR or PR.

9.4.2.2 Output Image to Video

Images,. e.g. cluster maps, generated by CLSTR will be displayed by and consistent with the requirements for IMD (see Section 7) and/or PR (see Paragraph 8.4.2).

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9.4.4 Digital Data

9.4.4.1 Detailed Clustering Report

This report will be generated on receipt of the appropriate menu inputs from the Cluster Summary Report (Paragraph 9.2.2.2). The inputs* will specify which clusters (maximum 4), from which "run", are to be used to generate the detailed report. The report "header" will identify the Run Number and Iteration Number (if applicable). The cluster numbers will be identified, and for each cluster, the following data will be displayed:

A. If the cluster resulted from a merge of two previous clusters, the ID number of those clusters.

B. If the cluster resulted from a split of two previous clusters, the ID number of those clusters.

C. The means of the cluster of all channels (spectral bands) used to define the cluster.

---

*Automatic except for "special action" request

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```
                              DETAILED CLUSTERING REPORT

RUN        CLUSTER  1      CLUSTER  2      CLUSTER  3      CLUSTER  4      CLUSTER  5
NO.        C OF O / O      C OF O / O      C OF O / O      C OF O / O      C OF O / O
 1         S FROM O        S FROM O        S FROM O        S FROM O        S FROM O

CHANNELS   MEAN    STD     MEAN    STD     MEAN    STD     MEAN    STD     MEAN    STD
   1       XXX.XX  XX.XX   XXX.XX  XX.XX   XXX.XX  XX.XX   XXX.XX  XX.XX   XXX.XX  XX.XX
   2
   3
   4
   5
   6
   7
   8
   9
  10
  11
  12
  13
  14
  15
  16
  17
  18
  19
  20
  21
  22
  23
  24       XXX.XX  XX.XX   XXX.XX  XX.XX   XXX.XX  XX.XX   XXX.XX  XX.XX   XXX.XX  XX.XX

 DIFF          XX.XX           XX.XX           XX.XX           XX.XX           XX.XX

DISTANCE
 MEAN         XXX.XX          XXX.XX          XXX.XX          XXX.XX          XXX.XX
 STDEV         XX.XX           XX.XX           XX.XX           XX.XX           XX.XX
```

PB

PF

RET

EOF

EOT

Figure 9.4.4.1-1 Detailed Clustering Report

Approved: ____________ NASA/DPB ____________ PHIO

9.4.4.2 Inter-Cluster Distance Table (ICDT)

This report will be generated keyed on a menu input via the Clustering Summary Report see Paragraph 9.2.2.3). It will refer to the set of clusters belonging to the "run" denoted on the CSR at the time of input. For that set of clusters the ICDT will show the "distance" between all pairwise combinations of clusters, and identify (by number) the pair corresponding to a given distance. The data will be displayed in columns in the order of increasing distance. The distance formula is:

a. ADAPTIVE;$D(I,J)= \Sigma_L \left| M_{IL} - M_{JL} \right|$

where:
M=Mean
L=Channel

b. ITERATIVE;$D(I,J)= \sqrt{\Sigma_L \frac{M_{IL} - M_{JL})^2}{\text{Sigma }(I,L) \times \text{Sigma }(J,L)}}$

where:
M=Mean
L=Channel Set
Sigma=Standard Deviations

Approved: ______________ NASA/DPB ______________ PHO

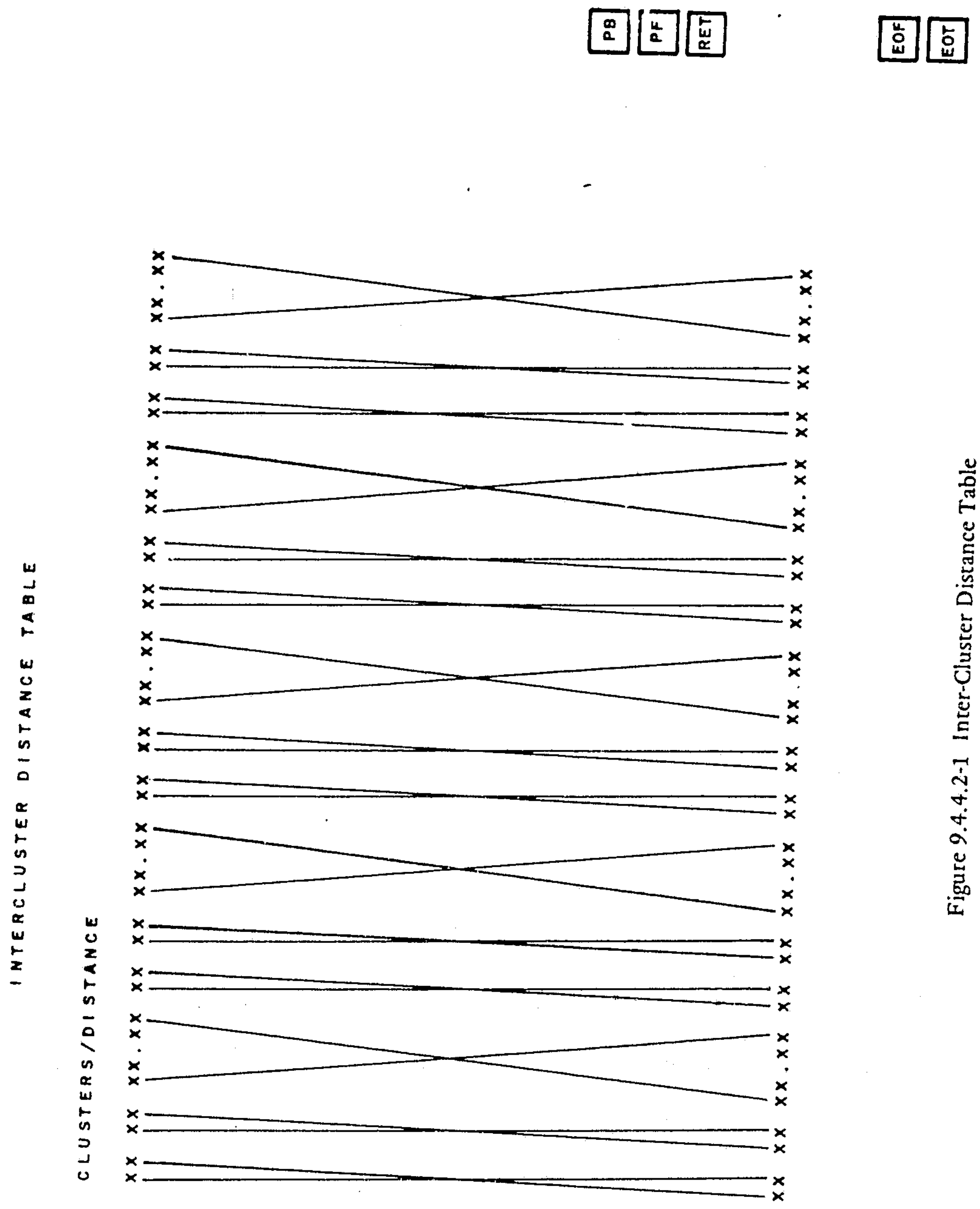

Figure 9.4.4.2-1 Inter-Cluster Distance Table

Approved: ____________________ NASA/DPB ____________________ PHO

SECTION 10

IMAGE CREATION REQUIREMENTS

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SECTION 10

IMAGE CREATION REQUIREMENTS

10.1 INTRODUCTION

The Image Creation Application will provide the user with the capability to manipulate the input imagery data in several specified manners. Also, a processor within the Image Creation Application will allow the user to generate several test images that may be used in any of the ERIPS applications. Specifically, the Image Creation Application will provide the user the capability to compose an image, difference two images, merge image subsets as in mosaicing, ratio channels of an image, create a subset of a loaded image, and to create test images.

Approved: ______________ NASA/DPB ______________ PHO

10.2 USER INTERFACE REQUIREMENTS

The ERIPS user will have the capability to select the Image Creation Application from the application selection menu after having signed onto the system and loaded the data necessary for the image creation processing. The Image Creation Application will also be accessible from the Pattern Recognition Application Image Specification Menu (Figure 8.2.2.2-1) via an Immediate Action control function.

Approved: ________________ NASA/DPB ________________ PHO

10.2.1 General Capabilities

All menus presented to the user in the Image Creation Application will include the capabilities to scroll the image(s), to select the image manipulation and display application, and to allow unloading and scratching from disk via error recovery logic, all without actually exiting the application. Also, the capability will exist to indicate the EOF (End-of-Field) and EOT (End-of-Transmission) on all menus without the use of the keyboard. The user may return to the previous menu by indicating a return on any of the menus in this application.

All displayed images in this application will include a position indicator (line and column) on the overlay of the upper right hand corner and the lower left hand corner. The corner positions will be updated when the image(s) scroll is halted.

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10.2.2 Processor Selection

Upon entrance to the Image Creation Application the user will be presented with a menu which will request specification of the image creation desired. The processors will consist of the following:

- Image Composition
- Image Difference
- Image Merge
- Image Ratio
- Image Subset
- Test Images
- Image Smooth

This menu is illustrated in Figure 10.2.2-1.

Approved: ____________ NASA/DPB ____________ PHO

IMAGE CREATION APPLICATION

IMD

SCR

PLEASE SELECT DESIRED OPTION:

- [ ] IMAGE COMPOSITION
- [ ] IMAGE DIFFERENCE
- [ ] IMAGE MERGE
- [ ] IMAGE MERGE
- [ ] IMAGE RATIO
- [ ] IMAGE SUBSET
- [ ] TEST IMAGES
- [ ] IMAGE SMOOTH

RET

EOF

EOT

Figure 10.2.2-1 Image Creation Application

Approved: ________ NASA/DPB ________ PHO

10.2.3 Image Composition Menu

When the user selects the Image Composition Processor the menu as represented in Figure 10.2.3-1 will appear. This menu will request the user to specify the name of the first image to be used in the composition and the channels of that image that are to be composed and then the identical information for the second image to be used in the composition. The user will then specify an ID or name for the image to be created and may type in comments to be associated with that image. The user may also unload or delete images when finished. It should be noted that the line and Pixel count of the two images must be identical.

Approved: TLP NASA/DPB RWS PHO

IMAGE COMPOSITION

ENTER NAME OF FIRST LOADED IMAGE TO BE USED IN COMPOSITION ____________ [IMD]

PLEASE ENTER CHANNEL NUMBERS TO BE USED IN ASCENDING ORDER [SCR]

__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ (THESE 'N' CHANNELS WILL BE
__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ DESIGNATED AS CHANNELS 1, 2, 3...N
ON COMPOSED IMAGE)

ENTER NAME OF SECOND LOADED IMAGE TO BE USED IN COMPOSITION ____________

PLEASE ENTER CHANNEL NUMBERS TO BE USED IN ASCENDING ORDER

__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ (THESE 'M' CHANNELS WILL BE
__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ DESIGNATED AS CHANNELS N+1, N+2,
N+3...N+M ON COMPOSED IMAGE)

PLEASE ENTER 12 CHARACTER NAME OF IMAGE TO BE CREATED ____________

AND ENTER COMMENTS TO BE ASSOCIATED WITH COMPOSED IMAGE: [RET]
(240 CHARACTERS MAXIMUM)

____

____

____

☐ CHECK BOX IF YOU WISH TO UNLOAD OR DELETE ANY IMAGES WHEN FINISHED [EOF] [EOT]

Figure 10.2.3-1 Image Composition Menu

Approved: ____ NASA/DPB ____ PHO

10.2.4 Image Difference Menu

The Image Difference Processor will present a menu to the user requesting the following: the names of the two images to be differenced, the name to be assigned to the output image and the channels to be differenced. This menu is shown in Figure 10.2.4-1. Again, it should be noted that the line and pixel count of the two images must be identical.

Approved: ______________________ NASA/DPB ______________________ PHO

IMAGE DIFFERENCE MENU

IMD

SCR

PLEASE TYPE NAMES OF IMAGES TO BE DIFFERENCED:

IMAGE 1 ____________
IMAGE 2 ____________

AND ASSIGN NAME TO OUTPUT IMAGE ____________

PLEASE CURSOR CHANNELS TO BE DIFFERENCED: ALL

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

RET

NOTE: NUMBER OF CHANNELS IN IMAGES MUST BE IDENTICAL
NUMBER OF LINES IN IMAGES MUST BE IDENTICAL
NUMBER OF PIXELS PER LINE IN IMAGES MUST BE IDENTICAL

EOF

EOT

Figure 10.2.4-1 Image Difference Menu

Approved: ____________ NASA/DPB ____________ PHO

10.2.5 Image Merge Menu

10.2.5.1 Menu 1

The menu shown in Figure 10.2.5-1 will be displayed when the user selects the Image Merge option on the Image Creation Processor selection menu. The user is able to specify on this menu up to four images which will be merged into a single contiguous image. The user, on this menu, selects only the bandlists to be merged from each input image. An error message will be displayed on the following input conditions:

(1) The number of channels selected on all input images is unequal (however, different channel sets are permissible), or

(2) A specified channel number on an input image does not exist.

The output image channel numbers will be redefined as 1 through N.

10.2.5.2 Menu 2

The menu shown in Figure 10.2.5-2 will be displayed on a satisfactory exit from Menu 1, above. The user is given optional horizontal (pixel coordinate) or vertical (line coordinate) merge capabilities. Under the horizontal option specification is made of the number of lines (of all images) to be extracted and the starting line in each image, as well as the starting and ending pixels in each image. The output image will then have the number of lines specified and the sum of the pixels specified. An error message will be generated if:

(1) the sum of the requested pixels exceeds 1000, or

(2) the line and/or pixel numbers requested do not exist on an input image.

The vertical merge capability is similar. The user also specifies the name assigned to the merged output image on this menu. A RET Immediate Action will return to the previous menu.

Approved: _[signature]_ NASA/DPB _[signature]_ PHO

```
IMAGE MERGE MENU 1

ENTER NAME OF FIRST TO BE MERGED _ _ _ _ _ _ _ _                         [IMD]
   ENTER CHANNEL NUMBERS TO BE USED IN ASCENDING ORDER                    [SCR]

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --   (NUMBER OF CHANNELS 'N' MUST BE
                                                   THE SAME FOR ALL MERGED IMAGES
-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --    AND WILL BE OUTPUT CHNS 1 - N)

ENTER NAME OF SECOND IMAGE TO BE MERGED _ _ _ _ _ _ _ _
   ENTER CHANNEL NUMBERS TO BE USED IN ASCENDING ORDER

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --

ENTER NAME OF THIRD IMAGE TO BE MERGED _ _ _ _ _ _ _ _
   ENTER CHANNEL NUMBERS TO BE USED IN ASCENDING ORDER                    [RET]

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --

ENTER NAME OF FOURTH IMAGE TO BE MERGED _ _ _ _ _ _ _ _
   ENTER CHANNEL NUMBERS TO BE USED IN ASCENDING ORDER

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --                          [EOF]

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --    HIT EOT TO CONTINUE   [EOT]
```

Figure 10.2.5-1 Image Merge Menu 1

Approved: ____ NASA/DPB ____ PHO

IMAGE MERGE MENU 2

PLEASE SELECT HORIZONTAL OR VERTICAL MERGE OPTION :

☐ HORIZONTAL ☐ VERTICAL

NUMBER OF LINES ____				NUMBER OF PIXELS ____			
IMAGE	START LINE	START PIXEL	END PIXEL	IMAGE	START PIXEL	START LINE	END LINE
1	____	____	____	1	____	____	____
2.	____	____	____	2	____	____	____
3	____	____	____	3	____	____	____
4	____	____	____	4	____	____	____

PLEASE ASSIGN NAME TO OUTPUT IMAGE ____________

HIT EOT TO MERGE

NOTE: PIXELS AND/OR LINES OF THE OUTPUT IMAGE WILL BE RENUMBERED, BEGINNING WITH 1, IN ACCORDANCE WITH THE INPUT IMAGE SEQUENCE.

IMD

SCR

RET

EOF

EOT

Figure 10.2.5-2 Image Merge Menu 2

10.2.6 Image Ratio Menu

The Image Ratio Processor will present a menu, as shown in Figure 10.2.6-1, to the user requesting the following: the image name of the image to be ratioed a name to be assigned to the output image, the portion of the image to be ratioed, the channels of the image to be ratioed, and a multiplication factor for the result. The user may default the portion of the image to be ratioed by cursoring the box for default boundary limits and ratio the entire image. Each pair of channels to be ratioed will constitute a channel of the output image, numbered in order of input. The multiplication factor will default to 100 and if the result of the ratio times the factor is greater than 255 that element will assume the value of 255.

Approved: ______________ NASA/DPB ______________ PHO

IMAGE RATIO MENU

IMD

SCR

PLEASE TYPE NAME OF IMAGE YOU WISH TO RATIO:

IMAGE NAME ____________

AND ASSIGN NAME TO OUTPUT IMAGE ____________

☐ CURSOR THIS BOX FOR DEFAULT BOUNDARY LIMITS

OR TYPE INITIAL LINE _____ AND FINAL LINE _____

INITIAL PIXEL ____ AND FINAL PIXEL ____

AND THEN TYPE CHANNEL PAIRS TO BE RATIOED

RET

PLEASE TYPE DESIRED CONSTANT MULTIPLIER___, DEFAULT=100

EOF

☐ CURSOR THIS BOX IF FURTHER PROCESSING IS DESIRED

EOT

Figure 10.2.6-1 Image Ratio Menu

Approved: ____ NASA/DPB ____ PHO

PHO-TR514
Change 4
3 June 1974

10.2.7 Image Subset Menu

The Image Subset Processor will simply allow the user to create subsets of a loaded or ERIPS generated image for further processing or for unloading. This will be done via the menu shown in Figure 10.2.7-1. The user will respond to this menu by specifying the image name of the image from which he wishes to select a subset, assigning a name to the output image, and selecting the line, pixel and/or channel subset values. The user will have the options as shown in Figure 10.2.7-1 of selecting dimension subsets with all channels, dimension subsets with selected channels or to default dimension subsets, i.e. the full dimension of the image, and select subsets of channels.

Approved: ______ NASA/DPB ______ PHO

IMAGE SUBSET MENU

PLEASE TYPE NAME OF IMAGE FROM WHICH YOU WISH SUBSET

IMAGE NAME ____________

AND ASSIGN NAME TO OUTPUT IMAGE ____________

[ ] CURSOR THIS BOX FOR DEFAULT BOUNDARY LIMITS

OR TYPE INITIAL LINE _____ AND FINAL LINE _____

INITIAL PIXEL ____ AND FINAL PIXEL ____

PLEASE CURSOR CHANNELS FOR SUBSET: [ALL]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

[ ] CURSOR THIS BOX IF FURTHER PROCESSING IS DESIRED

[IMD]
[SCR]
[RET]
[EOF]
[EOT]

Figure 10.2.7-1 Image Subset Menu

Approved: ______ NASA/DPB ______ PHO

10.2.8 Test Images Menu

When the user selects the test image option from the image creation options menu, he will be presented with the menu shown in Figure 10.2.8-1. This menu will offer the user the option of creating a background image, a grid image, or a function image simply by cursoring the box opposite the desire option. The user will then be presented with one of the menus as described in the following paragraphs.

10.2.8.1 Background Test Image Menu

The expected user response to the background test image menu (see Figure 10.2.8.1-1) will be a specified image name, an itensity of the first pixel, an intensity increment between pixels, and the dimensions of the output image, i.e., number of pixels and number of lines. Default will be first pixel intensity of zero with an intensity increment of 16 for an image the size of the image screen, i.e., 439 X 612.

10.2.8.2 Rectilinear Grid Image Menu

The menu shown in Figure 10.2.8.2-1 will be used to define a rectilinear grid image generation. The user will specify the number of elements per grid cell by pixel and line increments and then specify the dimensions of the output image by pixel and line values. Default will be a 50 X 50 grid cell image the size of the image screen.

10.2.8.3 Function Test Image Menu

Figure 10.2.8.3-1 is a representation of the function test image menu. The user will type in the coefficients of a general fifth order polynomial and specify the dimensions of the output image again by pixel and line values. The user must specify coefficient values here for the default will be zero values.

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RETURN

TEST IMAGES

IMD

LISTED BELOW ARE THE NAMES OF THOSE TEST IMAGES WHICH CAN BE LOADED FOR REGISTRATION.

SELECT, AT MOST, ONE FOR LOADING.

	IMAGE NAME	DESCRIPTION
☐	BACKGRND	ADJACENT PIXELS, UNEQUAL VALUES
☐	GRID I	STRAIGHT LINE GRID
☐	FUNCTION	GENERAL POLYNOMIAL

THIS MENU WILL REAPPEAR FOLLOWING THE LOADING OF A REQUESTED IMAGE
TO DISPLAY AN IMAGE, SELECT THE SPECIAL ACTION BOX LABELED IMD
TO RETURN, SELECT THE SPECIAL ACTION BOX LABELED RT.

RET

EOF

EOT

Figure 10.2.8-1 Test Images

Approved: ________ NASA/DPB ________ PHO

RETURN

BACKGROUND TEST IMAGE

THE BACKGROUND IMAGE IS ONE IN WHICH INTENSITIES OF ADJACENT PIXELS ON A LINE DIFFER BY A SPECIFIED AMOUNT (PIXEL INTENSITY VALUES ARE MODULO 256).

THE INFORMATION REQUESTED BELOW DEFINES BACKGROUND IMAGE WHICH WILL BE GENERATED. PLEASE ENTER DESIRED VALUES.

VALUE	DESCRIPTION	RANGE	DEFAULT
0 ______	IMAGE	12 CHAR MAX	BACKGRND
______	INTENSITY OF FIRST PIXEL	0 - 255	0
______	INCREMENT BETWEEN PIXELS	0 - 255	16
______	NUMBER OF PIXELS PER LINE	1 - 1000	512
______	NUMBER OF LINES PER IMAGE	1 - 1000	439

RET

EOF

EOT

Figure 10.2.8.1-1 Background Test Image

Approved: ______ NASA/DPB ______ PHO

RETURN

RECTILINEAR GRID IMAGE

THIS TEST IMAGE CONSISTS OF EQUALLY SPACED
HORIZONTAL AND EQUALLY SPACED VERTICAL LINES

THE INFORMATION REQUESTED BELOW DEFINES THE
GRID IMAGE WHICH WILL BE GENERATED.
PLEASE ENTER DESIRED VALUES.

VALUE	DESCRIPTION	RANGE	DEFAULT
0 ______	IMAGE NAME	12 CHAR MAX	GRID1
___	PIXELS PER GRID CELL	1 – 1000	50
___	LINES PER GRID CELL	1 – 1000	50
___	PIXELS PER LINE IN IMAGE	1 – 1000	612
___	LINES IN IMAE	1 – 1000	439

RET

EOF

EOT

Figure 10.2.8.2-1 Rectilinear Grid Image

Approved: ____________ NASA/DPB ____________ PHO

RETURN

FUNCTION TEST IMAGE

THE FUNCTION TEST IMAGE IS A GRAPH OF A GENERAL FIFTH DEGREE POLYNOMIAL WITH THE FORM

$$Y = A0 + A1 * X^1 + A2 * X^2 + A3 * X^3 + A4 * X^4 + A5 * X^5$$

AND IS GENERATED FROM VALUES ENTERED BELOW.

VALUE	DESCRIPTION	RANGE	DEFAULT
0	IMAGE NAME	12 CHAR MAX	FUNCTION
	A0		0.0
	A1		0.0
	A2		0.0
	A3		0.0
	A4		0.0
	A5		0.0
	PIXELS PER LINE IN IMAGE	1 - 1000	612
	LINES IN IMAGE	1 - 1000	439

NOTE: COEFFICIENTS ARE FLOATING POINT NUMBERS.

RET

EOF

EOT

Figure 10.2.8.3-1 Function Test Image

Approved: ______ NASA/DPB ______ PHO

10.2.9 Image Smooth Menu

When the user selects IMAGE SMOOTH on the Image Creation Processor selection menu the Image Smooth menu will be displayed (Figure 10.2.9-1). The user is able to specify on this menu an image or image subset to be smoothed, and the channel set he requires for creation of the output image. The channel numbers of the output image are the same as those input. The user is also able to specify the size of the output image via the expansion factor (an integer) and the interpolation limits via the window size (an odd integer less than twice the expansion factor). The data range of the output image is controlled as a function of the input data value and the two data ranges specifiable.

Error messages will be displayed on the following input specification conditions:

- Number of pixels in input image (subset) line exceeds 500
- Number of pixels in input image times expansion factor exceeds 1000
- Output image size predicted to be greater than 10 elements
- Window size greater than twice the expansion factor
- Specified channels do not exist
- Specified data ranges outside the limits 0 to 255

Approved: TJP NASA/DPB RMS PHO

IMAGE SMOOTH

[IMD]

INPUT IMAGE ------------ OUTPUT IMAGE ------------

INPUT CHANNELS TO BE PROCESSED (TO USE ALL CHANNELS LEAVE BLANK)

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --

-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --

SUBSET OF INPUT IMAGE TO BE PROCESSED :

FIRST PIXEL ----
NUMBER OF PIXELS ----
FIRST LINE ----
NUMBER OF LINES ----

EXPANSION FACTOR -- NOTE : THE WINDOW SIZE MUST BE LESS THAN TWICE THE EXPANSION FACTOR AND ODD.

WINDOW SIZE -- [RET]

DATA RANGE EXPANSION

INPUT DATA RANGE FROM --- TO ---

OUTPUT DATA RANGE FROM --- TO ---

[EOF]

[EOT]

Figure 10.2.9-1 Image Smooth

Approved: ______ NASA/DPB ______ PHO

10.3 PROCESSING REQUIREMENTS

10.3.1 Image Composition P ocessor

This processor will take two input images and create one output image from the composition process. The processing requirements will be to simply renumber channels and rearrange the image into a format suitable for processing by the other ERIPS applications. The output channels will be renumbered consecutively beginning at number 1 where the channels from the first image will be 1, 2, 3 ... N of the output image and the M channels of the second image will be N+1, N+2, N+3 ... N+M of the output image.

Approved: ________ NASA/DPB ________ PHO

10.3.2 Image Difference Processor

The Image Difference Processor will simply difference the two input images to generate an output image. This difference will be d·ne as follows

$$D_{\ell,p} = \left| X^N_{\ell,p} - X^M_{\ell,p} \right|$$

Where: $D_{\ell,p} = (\ell,p)^{th}$ component of the output image

$X^N_{\ell,p} = (\ell,p)^{th}$ component of the first input image

$X^M_{\ell,p} = (\ell,p)^{th}$ component of the second input image

The difference will be taken on a channel by channel basis such that, if two images of N channels each are differenced, the output image would contain N channels, also.

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10.3.3 Image Merge Processor

The Image Merge Processor will create an output image from the two- to four-input images, replacing all channel numbers with a sequential set of channels beginning with 1, and all line and pixel coordinates with a new set beginning at line 1 and pixel 1. The output coordinate (1,1) is defined as the lowest line and pixel pair in the first image subset on Menu 1 of the Merge application. Defining p_ℓ as the number of pixels in the first image, in the horizontal merge option the coordinate in the output image of the lowest numbered line/pixel coordinate from the second image will be (p_ℓ +1,1). This convention is extended through all input images and is applicable for line numbering in the vertical merging option.

Approved: TAP NASA/DPB R.W.S PHO

10.3.4 Image Ratio Processor

The Image Ratio Processor will simply ratio specified channels of an input image and multiply that result by a user-specified constant (default = 100) to create an output image with channels numbered beginning at 1 to N where N is the number of ratios specified.

This will be done as follows:

$$R^{K}_{\ell,p} = C\left[\frac{X^{N}_{\ell,p}}{X^{M}_{\ell,p}}\right]$$

Where:

$R^{K}_{\ell,p}$ = output of line, ℓ, pixel, p, for resultant channel K

C = specified constant, default - 100

$X^{N}_{\ell,p}$ = input of line, ℓ, pixel, p, for the first specified channel, N

$X^{M}_{\ell,p}$ = input of line, ℓ, pixel, p, for the second specified channel, M

Approved: TJP NASA/DPB RWS PHO

10.3.5 Image Subset Processor

The processing requirements for the Image Subset Processor will be to simply pull the required subset from the original image and place the image subset onto disk in order to allow further processing by the ERIPS of only that subset of the input image. No renumbering of lines, pixels or channels is required.

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10.3.6 Test Images Processor

10.3.6.1 Background Test Image

The Background Test Image Processor will simply create an image from the user specified inputs requiring simple additions and multiplications and store that image on disk for further use by the ERIPS.

10.3.6.2 Rectilinear Grid Image

Again, this processor will simply create an image from the user specified inputs requiring simple operations and store that image on disk for further use by the ERIPS.

10.3.6.3 Function Test Image

The Function Test Image Processor will require the evaluation of a general fifth order polynomial to generate the output image again to be stored on disk for further ERIPS use. The polynomial will be of the form:

$$Y = A_o + A_1X + A_2X^2 + A_3X^3 + A_4X^4 + A_5X^5$$

where A_o, A_1, A_2, A_3, A_4, A_5 are user inputs and Y and X are the coordinate system of the image screen.

Approved: ______ NASA/DPB ______ PHO

10.3.7 Image Smooth Processor

10.3.7.1 Introduction

The data smoothing technique is a multiple bilinear interpolation of adjacent measurement data from an input image to create an output image of increased size. The technique has utility in the creation of film products from "small" images or subsets in which strict data integrity is not mandatory and where it is desired (for presentation or display purposes) to avoid the visual granularity of data elements under standard pixel-repetition techniques. The current scheme eliminates this visual granularity while retaining a generally correct (visual) representation of the image data. The output image may then be stored on the image disk in Universal format.

10.3.7.2 Description

A. Applicability

An image (or defined subset of a loaded image) with less than 500 pixels/line may be smoothed. Any or all channels of such an image or subset may be specified simultaneously for smoothing. The channel numbers of the smoothed output image will correspond to the input image channel numbers.

B. Concept

Subsequent discussion is based on a single channel of an input image containing L lines and P pixels/line. The measurement value at a point in the channel is X (p,l). The operation of the algorithm is primarily determined by the following user inputs:

- Scale Factor: M = positive integer, such that $MP \leq 1000$
- Window Size: W = odd, positive integer $< 2M$.

The scale factor defines the size of the output image (MP x ML) and, therefore, the number of interpolations to be performed between each input pixel and its adjacent neighbors.

The adjacent pixels to a point (p,l) in the input image are defined in Figure 10.3.7-1 and denoted in terms of their respective measurement values. A notational convention is adopted which will simplify later expressions.

For purposes of discussion (although the actual manipulation is not required by the formulation) the input image is considered to be magnified by M, with each input pixel becoming M^2 identical data elements in the magnified image. The mechanism of the interpolation is the replacement of each new data point with an appropriately smoothed value, which is a function of the data values at the point and the defined adjacent points.

Approved: [signature] NASA/DPB [signature] PHO

X_2 = X (p-l, 1+l)	X_6 = X(p,l+1)	X_3 = X (p+l, 1+l)
X_5 = X (p-l,1)	X_9 = X (p,l)	X_7 = X (p+l, 1)
X_1 = X (p-l,1-l)	X_8 = X (p,1-l)	X_4 = X (p+l, 1-l)

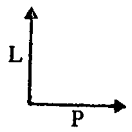

Figure 10.3.7-1 Adjacent Pixels to (p,l)

The window size determines the magnitude of the effect of each adjacent data element in the determination of the smoothed output data element. W represents the integral side of a square of pixels in the magnified input image, centered on the pixel of interest, Figure 10.3.7-2. The output data value is the simple average of all pixels within the square. In the following expressions, W has been constrained as odd to simplify complications and is limited to $< 2M$ for consideration of only the specified input data values.

The process, for the set of M^2 data points associated with a given input pixel (p,l), is repeated by centering the window on each data point and calculating the average of the W^2 values. For efficiency of operation, a functional relationship between the output value, and M and W has been developed for each of these M^2 points, which obviates the necessity for building the magnified input image.

C. Program Operation

Let a given data point in the (magnified) input image be designated:

X_{ab} (p,l)

where a = pixel displacement "within" the original input

pixel X (p,l), $1 \leq a \leq M$

b = line displacement, similarly defined, $1 \leq b \leq M$.

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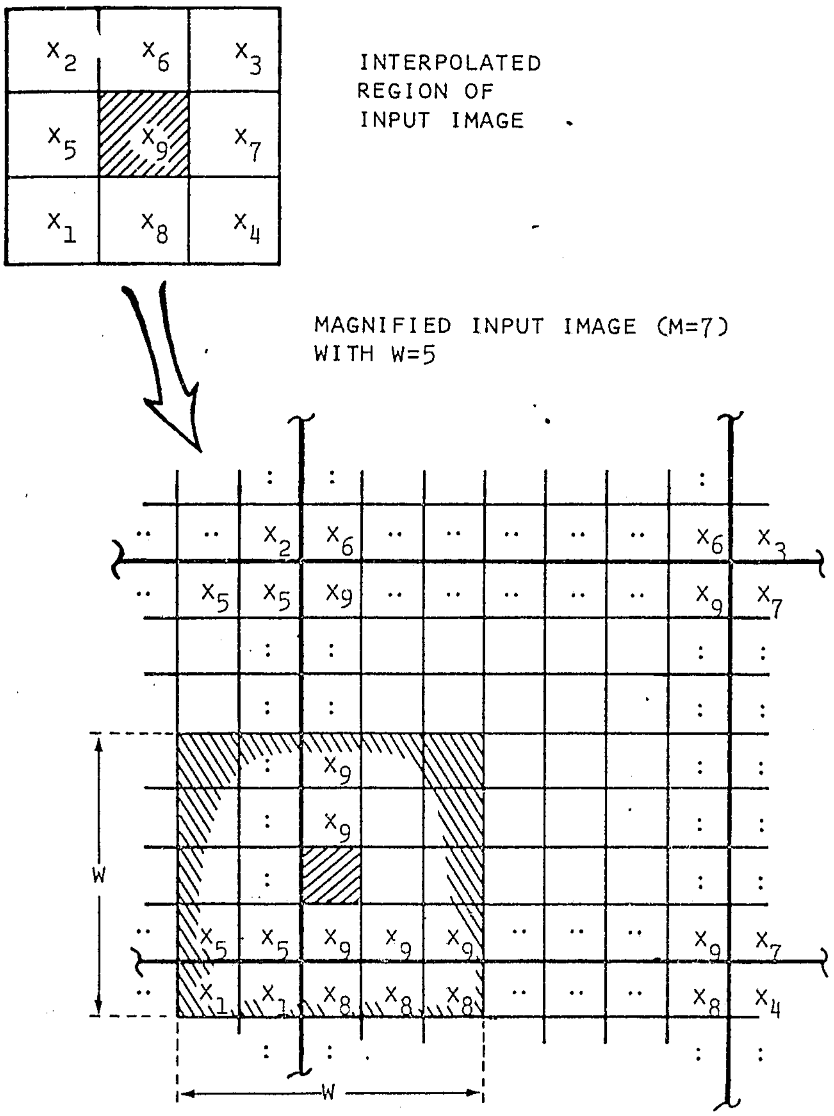

Output value of shaded pixel [element of x (p,1)] is given by:

$$\frac{1}{(5)^2}\left(2X_1 + 8X_5 + 3X_8 + 12X_9\right)$$

Figure 10.3.7-2 Sample Calculation of an
Output Data Value

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All X_{ab} (p,l) have the same data value from X (p,l). For a given a and b, the number of pixels within the window square which belong to each of the considered input pixels is designated:

$$F_{i,ab}$$

where i = 1, 2, ... , 9; associated with the X_i of Figure 10.3.7-1 for a given a,b:

$$F_{i,ab} = f\ (M,W)$$

and the average of the data elements in the window around a,b is:

$$X'_{ab}\ (p,l) = \frac{1}{W^2} \bullet \sum_{i=1}^{9} \bullet \left(F_{i,ab} \right) \bullet X_i \qquad (1)$$

The initial step in the program is the calculation of the values of $F_{i,ab}$, which are stored as a set of 1x9 vectors for each ab. The computation is given in subsequent paragraphs. These M^2 vectors are then applied in equation (1) to each input pixel and its neighboring pixels, iterating through a and b to create M^2 output data points from each input pixel of the image. The output image is then an image of dimension MP x ML.

D. Additional Considerations

It may be desirable to modify (in general, increase) the significant data range of the output image. Therefore, the equation for the output data value at every point can be modified to:

$$X'_{ab}\ (p,l) = k'_1 + \left(\frac{k'_2 - k'_1}{k_2 - k_1} \right) \left(\frac{1}{W^2} \right) \sum_{i=1}^{9} \left(F_{i,ab} \right) X_i \qquad (2)$$

where k_1, k_2 are the specified input data range limits,

$$0 \leq k_1 < k_2 \leq 255$$

and k'_1, k'_2 are the specified output data range limits,

$$0 \leq k'_1 < k'_2 \leq 255$$

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10.3.7.3 Program Requirements

A. Controls

Controls are specified in Paragraph 10.2.9-1 and Figure 10.2.9-1. Control errors will be flagged via appropriate messages. Default values will be provided only for the data ranges (0 - 255 in both cases) and for subset definition (default to entire image). Failure to speicfy other parameters will result in an error message.

B. Processing Requirements

1. A set of M^2 1x9 vectors will be calculated upon entry to the program. These vectors contain components as described in subparagraph 10.3.7.2C. The vectors are:

$$F_{ab} = \left[F_{1,ab} \quad F_{2,ab} \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad F_{9,ab} \right]$$

where $1 \leq a \leq 9$ and $1 \leq b \leq 9$ and the F_i are related to the X_i of Figure 10.3.7-1.

From strictly geometric considerations the following values have been derived from the F_i associated with an (a,b) pair. These values will be computed for each such pair, using the notation

$$S = \text{INT}\left[\frac{W}{2}\right] \quad (1)$$

$$F_1 = (S+1)^2 - (S+1)(a+b) + ab$$

computed for $1 \leq a \leq S$, $1 \leq b \leq S$, otherwise 0.

$$F_2 = S^2 - S(a-b+M-1) + (a-1)(M-b)$$

when $1 \leq a \leq S$, $0 \leq M-b \leq S$, otherwise 0.

$$F_3 = S^2 - S(2M-a-b) + (M-a)(M-b)$$

when $0 \leq M-a < S$, $0 \leq M-b < S$, otherwise 0.

$$F_4 = S^2 - S(b-a+M-1) + (M-a)(b-1)$$

when $0 \leq M-a < S$, $1 \leq b \leq S$, otherwise 0.

$$F_5 = W(S-a+1) - F_1 - F_2$$

when $1 \leq a \leq S$, otherwise 0.

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$F_6 = W(S-M+b) - F_2 - F_3$

when $0 \leq M-b < S$, otherwise 0.

$F_7 = W(S-M+a) - F_3 - F_4$

when $0 \leq M-a < S$, otherwise 0.

$F_8 = W(S-b+1) - F_1 - F_4$

when $1 \leq b \leq S$, otherwise 0.

$$F_9 = W^2 - \sum_{i=1}^{8} F_i$$

The M^2 vectors thus calculated are stored for subsequent use.

2. The smoothing algorithm will be performed using the calculated F vectors on each pixel of the input image to create M^2 output pixels as follows:

$$X'_{ab}(p, l) = k_1 + \left(\frac{k'_2 - k'_1}{k_2 - k_1}\right)\left(\frac{1}{W^2}\right) \sum_{i=1}^{9} \left(F_{i,ab}\right)\left(X_i\right) \qquad (2)$$

for $1 \leq a \leq M$ and $1 \leq b \leq M$

with all terms as defined in Paragraph 10.3.7.2.

The convention is adopted in the case of an input pixel which is a boundary pixel of the image of subset is that the X (p,l) is extended horizontally or vertically to create the appropriate X_i which would be outside the input image or subset.

The X'_{ab} (p, l) will be calculated as 32-bit floating point values and rounded to the nearest integer for creation of the output image.

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10.4 OUTPUTS

The output product of all the processors within the image creation application will be an image as specified by the user that is in a format compatible for use throughout the EFIPS.

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